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Northern Region

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PROCEEDINGS --- NORTHERN REGION BIODIVERSITY WORKSHOP

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Missoula, MT, September 11-13, 1990

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FORWARD

The Northern Region and Intermountain Research Station Biodiversity Workshop was designed to present the best available current information and immediately reinforce the formal presentations with short facilitated workshops addressing the kinds of specific questions managers are expected to answer. Formal publication of proceedings from the Biodiversity Workshop were not originally planned for. These proceedings were compiled in response to the high interest expressed from workshop participants in having written copies of the presentations. Unfortunately we were unable to assemble copies of all presentations made at the workshop. The presentations made by Dr. Fred Allendorf, Dr. Reed Noss, Jodie Miller, and Margie Ewing are not available in these proceedings. Dr. Allendorf and Dr. Noss recommend that participants refer to several of their publications in the current conservation biology literature. Their published work covers the overall content of the presentations they made at the workshop.

The overall workshop was broken into five sections, each with a series of presentations followed by individual workshop groups. The five sections were: 1) Setting the Stage, 2) Plant Communities, Species and Genetics, 3) Wildlife and Fisheries, 4) Inventory and Assessment, and 5) Putting it Together.

The workshops were structured to include managers with a broad range of practical experience. The questions posed for the individual workshops do not in all likelihood, have specific answers. The solutions proposed by workshop participants are presented as a beginning checklist of considerations likely to be important in the long-term maintenance of biodiversity on the National Forests. As we gain experience and monitor results, modifications to these considerations will almost certainly be necessary. Summaries of individual workshops begin on page 72 of these proceedings.

The Northern Region Biodiversity Workshop was planned and organized by the R1/INT Biodiversity Committee. The four co-chairs for workshop were: Arlene Doyle and Angela Evenden, Northern Region; Jack Lyon, Intermountain Research Station; and Rob DeVelice, Montana Natural Heritage Program.

The success of the workshop can be attributed to all participants. Appreciation is also extended to all speakers who provided us with their insights and knowledge. Special thanks to the following workshop facilitators who worked hard prior to, during, and after the workshop: Tom Donahue, Sherry Munther, Deanne Riebe, Vic Dupuis, Marcia Hogan, Cliff Mitchell, Rich Raines, and Michael Stewart.

* * * *	**Setting the Stage**	* * * *

Session Chair: Arlene Doyle

Welcome to Workshop
Christopher Risbrudt, R.O.
Arlene Doyle, R.O.

New Perspectives in Biodiversity
Chip Cartwright
Asst. Director of New Perspectives

Legal Requirements for Biodiversity
Jody Miller
Attorney, OGC

Biodiversity and Appeals
John McGee, W.O.
Appeals Coordinator

Biodiversity
Bob Naumann, R.O.
Asst. Director of Silviculture

Characterization of Biodiversity in the Northern Region
Wendel Hann, R.O.
Regional Ecologist

Session Chair: Angela Evenden

How Land Management Affects Biodiversity
Miles Hemstrom,
Willamette N.F., Ecologist

Shasta Costa: From a New Perspective
Kurt Wiedenmann
Siskiyou N.F., Forester

White Sands as a Model for New Perspectives
Margie Ewing
Powell, R.D., District Ranger

Landscapes and Ecosystems
Reed Noss
Corvallis, OR, Ecologist and Conservation Biologist

Workshop 1A -- *What considerations are important in dealing with fragmentation?*

Workshop 1B -- *How do we establish baseline conditions to measure the success of landscape management?*

NEW PERSPECTIVES IN BIODIVERSITY

Charles Cartwright
Assistant Director of New Perspectives

Global trends in economies and the environment, people's desires for diverse lifestyles and quality of life, and new understandings about how ecosystems function are driving new approaches to sustainable multiple-use resource management. "New Perspectives" for sustainable, multiple-use and multiple value management of the National Forests and Grasslands is one of these pathways. New Perspectives is the Forest Service's approach for managing forests and rangelands to sustain their full array of values and uses. The approach emphasizes multiple-use management with equal attention to the multiple values of healthy and productive wildlands.

The Forest Service initiated New Perspectives in winter 1990 to help guide changes in overall program direction. These changes are a direct result of refinements in the philosophy, knowledge, and direction for multiple-use management brought about by: 1) the National Forest Management Act of 1976, 2) new research findings, 3) the changing expectations of Americans for what they want their National Forests and Grasslands to be, and 4) the growing diversity and technical skills of Forest Service employees.

The aim of New Perspectives is to highlight new approaches to sustainable, multiple-use management through renewed commitment to our land ethic, greater responsiveness to people's concerns, and acceleration of our continual search for management practices that sustain diverse and productive ecosystems while providing resources that people need. The management practices, based on experience and new scientific knowledge, are important parts of New Perspectives. In fact, they are essential parts. Management practices alone are not sufficient for socially desirable forest and rangeland management. A fresh attitude about health and better ways of working with people are equally essential.

Forest Service leaders have spent a lot of time over the past few years listening, seeing what people were up to, reading, discussing, thinking, planning, and critiquing programs and processes to better understand the need for change and its implications for future agency direction. The change is now well underway. This is an overview of what New Perspectives is, and what the Forest Service will be doing over the next few years to better realize the multiple-use ideal--its relationship to biological diversity.

New Perspectives, Forest Plans, and New Forestry

Let us begin this overview by putting New Perspectives into context. As with many new things, there is some confusion about what New Perspectives is, especially its relationship to Forest Plans and to New Forestry. New Perspectives is an attitude, an approach, and a philosophy about how to carry out multiple-use land and resource management in the public trust. New Forestry is a set of practices for managing forests with greater sensitivity to environmental values. Forest plans provide the framework for bringing new ideas and goals; as well as including and providing for biological diversity methods into land and resource management direction. They are the foundation for New Perspectives and for New Forestry.

New Forestry is silviculture designed to yield forest products while perpetuating forests with high amounts of ecological structure and function at both stand and landscape scales. It is based on the premise that forests provide a wide array of material resources and ecological services, timber being only one of the resources and not always the primary one. New Perspectives addresses the full range of wildland ecosystems, including rangelands, wetlands, and deserts, and blends the social and ecological dimensions of sustainable resource management. In addition to sustaining the yields of forest and rangeland resources

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for people, long-term goals for sustainable, multiple-use management include conserving the diversity of plant and animal communities (the variety of life, including the processes of life) and sustaining the productivity of soils and water.

Managing forests and rangelands for such a wide array of values and uses is more complex and uncertain that emphasizing sustained yields of a few resources such as timber, deer, trout, water, recreation, and forage. It requires better integration of science and technology with management, increased use of monitoring and evaluation in conservation strategies, and greater participation of citizens in the development and application of management actions.

Thus, New Perspectives builds a concept of "ecosystems management as applied science with social considerations." It addresses the same timeless goal of multiple-use management: diverse and productive land for all values and uses. But the New Perspectives approach is more comprehensive than we've used in the past. It brings the full array of social, biological, political, and physical sciences into ecosystems management in an integrated manner.

New Perspectives is Some Old, Some New, and Some Yet To Come

The New Perspectives approach, in the words of Chief Dale Robertson, is "some old, some new, and some yet to come." The "old and the new" come from our long history of experience in natural resource management, from tried-and-true methods, from recent advances in scientific knowledge, and from new directions in the RPA Program and forest and research plans.

The "yet to come" requires testing new ideas, new scientific disciplines such as conservation biology and landscape ecology, relatively new concepts such as biological diversity and collaborative problem solving; recent technologies such as geographic information systems and integrated resource management, and better ways for people to work together. The results of these explorations will guide continual adjustments in forest and research plans and future direction of the agency.

Themes and Principles for New Perspectives

From informal, but extensive, surveys of what Forest Service field people are doing to shape New Perspectives, we have found two themes and five principles that characterize the New Perspectives path at this time. Together, these themes and principles provide a guiding philosophy under which people at local levels shape what actually happens on the land and how people participate in that process.

Stewardship and a Land Ethic

The overarching themes of New Perspectives are stewardship: nurturing the assets of others; and a land ethic: improving the harmony between people and land. Both require balance in meeting the immediate needs of people for resources, while sustaining long-term land health.

Stewardship and land ethic make people feel good about what they are doing. But they are also somewhat fuzzy concepts for managers to deal with. Therefore, some guiding principles are needed to help managers know what they mean on the land.

Sustainability

Sustainability is the foremost principle of multiple-use management, hence of our New Perspectives as well. Sustainability means that forests and rangelands are managed for all their values and uses through the perpetuation of diverse and healthy biological systems, and conservation of soil and water productivity. Sustainability recaptures the original philosophy of the sustained-yield concept: that the yields are not sustainable unless the system that produces those yields is sustainable. This is where biodiversity enters in.

Partnerships

Partnerships with people in carrying out multiple-use management of public assets is the second principle of New Perspectives. Partnership means an extension of interdisciplinary teams to include a broader array of people and expertise in how plans and projects are developed. The best way to assure that you are responsive to people's needs and concerns is to get the people who are interested in, or affected by, what you are considering to help shape and carry out the decisions. This goes beyond the minimal requirements of the National Environmental Policy Act of 1969 for public involvement and certainly well beyond the old notion that only professional managers know what is best for the land or for people.

Collaboration

Collaboration among scientists, managers, educators, and communicators is a third principle of New Perspectives. Sustainable, multiple-use management is becoming so complex and contains so many uncertainties that we must increasingly use our management programs as large, ongoing experiments from which we continually gain knowledge and make adjustments. Doing this requires that the best scientific thought and technologies be employed in all planning, management, and communication activities, including monitoring and evaluating the results of those activities.

Integration

A fourth principle of New Perspectives is integration of all the resources and values of the land in planning and management. Ecosystem management must consider the cumulative effects of actions on all the values and uses of the system, up and down geographic scales and over long periods of time. What this means, as one example, is that when deciding how to manage a forest stand, a stream reach, or a range site, the manager thinks of the effects of possible actions on the solids, waters, plants, and animals within the stand or site as well as the role of the future stand, reach, or site in the landscape of which it is an integral part. Obviously, new technologies such as geographic information systems, integrated resources management, and cumulative effects analysis are crucial tools in carrying this out.

Innovation

Finally, the continual search for appropriate technologies, what we might call innovation, is the fifth principle of New perspectives. With more and more people expecting more things from public lands, including a better protected environment, we need management practices that are environmentally sensitive, aesthetically acceptable, and ecologically sustainable.

The themes of stewardship and land ethic, and the five principles of sustainability, partnerships, collaboration, integration, and innovation characterize how people in the field are shaping the New Perspectives path. But, just as plans are dynamic, these principles will undergo continual refinement as well. I realize there are gray zones among the principles and that we are likely to find concepts that are not captured by them. Further, we may find that there are better ways to describe them.

Biodiversity Through New Perspectives

New Perspectives includes programs to conserve gene resources, to recover and conserve endangered species, to restore and protect all kinds of biological communities, and to manage populations of species desired for sustainable commercial, recreational, and subsistence uses.

Yet, the biodiversity concept is also too complex to capture in a single technical definition. For this presentation let's just define it to be the variety of all life forms and life processes--a complex web of life. It includes all life forms from bacteria, fungi, and protozoa to higher plants, insects, fishes, birds, and mammals. World-wide, that could be as many as 30 million different species, plus all the processes and cycles that link organisms into populations, communities, ecosystems, and ultimately the biosphere. I am not a scientist but an observer of human kind, and I believe that it may not

be possible to have each and every aspect of life and its processes.

Nevertheless, conserving major portions of biological diversity, including a healthy global ecosystem, is vital to providing a future with productive, sustainable natural resources. But growing human populations means that we must continually make choices on which aspects of the variety of life are of highest priority for conservation and how we should blend their perpetuation with other social goals. The big questions we face on the future diversity of life on Earth include: What is biodiversity? What are the threats to its future? What parts and processes of biological diversity are of highest immediate concern? Why should we be concerned with perpetuating those parts and processes? and How should we go about conserving biodiversity while satisfying the other needs of people for food, shelter, clothing, recreation, and livelihood? We'll be many years getting comprehensive answers to these questions. But we need not wait for scientific consensus before embarking on a path to conserve what we already know to be some of the most important parts and processes.

The Nature of Biodiversity

So, aside from being the variety of life and its processes, just what specifically is biological diversity? Because it is extraordinarily complex and much of it is hidden from easy view, I found some "handles" to describe its most significant, measurable parts and processes.

The most basic component of biodiversity is *Genetic Variation*. Genetic variation affects a species' physical characteristics, productivity, resilience to stress, and long-term evolutionary potential. Genetic diversity means that species contain natural levels of genetic variation within and among their populations, including representation of extreme populations.

A second, usually more easily recognized aspect of biological diversity is distinct *Species*. Species diversity means that an area contains its native species in numbers and distributions that contribute to both natural genetic variation and a high likelihood of long-term continued existence throughout their geographic ranges.

Associations of species in an area are a third recognizable component of biological diversity. We refer to these associations as *Biological Communities*, and usually recognize them as distinct stands, patches, or sites, such as forests, meadows, fence rows, ponds, riparian areas, and wetlands. Biologically diverse communities contain sufficient compositional, structural, and functional variety that they are assured a high prospect of continued presence and ecological influence in the area.

Finally, at the geographic scale of *Regional Landscapes*, diversity includes variety in the kinds of biological communities and a biogeography (that is patterns, sizes, shapes, juxtapositions, and interconnectedness) that provides for free, natural interchange of individuals throughout the area. Many species, especially those with specialized habitat affinities or that are migratory or wide-ranging, can only be sustained in viable numbers and distributions in very large wildland areas. Biologically diverse regional ecosystems contain their full complement of species and biological communities with sufficient genetic variation, population viability, and compositional, structural, and functional integrity that the full range of natural processes, including evolutionary potential, is sustained. Such ecosystems might be thought of as being intact or possessing full biological integrity.

Threats to Biological Diversity

Why all the concern for this variety of life? Simply put, because we're losing parts and processes of biological diversity at alarming rates and we're not sure of the long-term consequences for future environmental health or quality of human life. At best, science and resource management will have minor lasting effects on biological diversity if social and political systems do not come to grips with the global "megathreats" of human population growth, poverty, pollution, and political instability. These megathreats to biodiversity are a reality; we cannot wish them away or ignore them.

We are here to share knowledge on: how to conserve those elements of biological diversity that can be influenced by the plans and actions we control. This is a beginning.

Values of Biodiversity

We are dealing with a finite resource, we cannot perpetuate all biological diversity while extracting an increasing portion of its productivity for growing human uses. So, what should we care about first? We know only a small fraction of the species on this planet; nevertheless, we can begin by addressing those elements of biological diversity that we already know are important to save and provide a "safety net" for the remainder we do not know about or understand.

Perspectives on a Conservation Strategy for Biodiversity

To accomplish this, we need a strategy that recognizes humans and change as fundamental to any solution. It will also require the recognition and use of regional ecosystems to provide a context for long-term planning and coordination of public and private actions.

It must integrate many goals and considerations. It must also employ a full spectrum of conservation actions from protection, restoration, enhancement, and sustainable harvest to meet human needs, to research, inventory, assessment, planning, monitoring, interpretation, marketing, and education. We will need to deal with issues on a larger scale than we have in the past. We will need to embrace the complexity of the issue and realize that there are no simple solutions. We need to recognize that biodiversity is a political issue, and taking action to conserve biological diversity will entail changes in social priorities and, hence, changes in current conservation policies, plans, and practices. Above all we need to realize that making those changes will be difficult. To make this work, agencies must open their planning and resource management processes even more than has occurred under federal and state environmental regulations and planning processes and we will have to enhance the role of science in management. We'll need some new knowledge and technologies. We can no longer afford the illusion that the only role of science is to yield pure knowledge and that development and application of that knowledge are someone else's business.

Summary

The keys to success on a strategy to conserve biodiversity are integration and on-the-ground action. Each of us has a very vital role to play and achieving the objectives of the Keystone Conference for Biodiversity is not a job for those weak of heart. Trying to conserve something that is so varied, so important, threatened by so many factors and so complicated to address will test the mettle of those who take on this challenge.

New perspectives in Forestry is the Forest Service's pathway from which the conservation of biological diversity, while meeting people's needs for resources is being addressed. Its guiding principles of participation, collaboration, integration, sustainability and innovation intimately match the implementation needs of achieving biodiversity. Its philosophy is characterized by on the ground practices that will strive to carry out a land ethic that does no harm, that heals the wounds, that meets peoples needs, that renews healthy land and provides learning opportunities.

The call to conserve biodiversity is one of change. What I have just shared with you is a focused attempt by Forest Service leadership to deal with change. Every generation has had to confront the need for change. And each generation has come with the best approach they could under the knowledge and social forces of their time. The approaches of the past were appropriate to those knowledges and those forces. But they were developed to serve the past. It is time to stand on the foundations of those who have gone before us, to build on their accomplishments, to learn from their successes and their mistakes. Biodiversity is all life and its processes. New Perspectives seeks to sustain both the natural resources our society needs and the diverse ecosystems which support these life forms. New Perspectives is the Forest Service's approach to managing forest and rangelands to sustain their full array of values and uses in an environmentally, socially acceptable manner. The effort is considerable, yet together we must succeed. The health and well being of our world depend on it.

BIODIVERSITY AND APPEALS

John McGee
WO Appeals Coordinator

Appeals and lawsuits are most often considered a negative result of our decision-making process. It is difficult to view an appeal as positive input to this process, even when a decision is affirmed and especially when it is not. So, in an attempt to focus on the positive aspects of appeals and lawsuits, first you must not lose sight of past appeal decisions. You must build your next decision on these points; I still believe in the old adage about re-living the past if you ignore it. In a sense, appeals are the crazy glue that binds laws and regulations with what is happening on the ground. If the public doesn't like or understand what we are doing in the woods, they appeal based on what they think we should be doing relative to their understanding and interpretation of the laws and regulations. Therefore, appeals are often kind of crazy.

Unfortunately, appeals and lawsuits don't tell us what to do in the future; they only tell you if what you did in the past was right or wrong. It is inevitable we will continue to have appeals; we can't satisfy everyone's interpretation of the laws and regulations. With more and more publics appealing and suing us, we are going to see and hear more and more different interpretations. Moreover, the appeals we are receiving are more and more sophisticated, well founded, scientifically based, and well-written. They are directly challenging our understanding and application of laws and regulations. We need to get ahead of this power curve or we will be whip-lashed by it into management decisions we are not totally comfortable with.

Let's review quickly the legal framework. There are three laws that relate directly to biological diversity:

NEPA: Title I, Sec. 101 (b) (4) : preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choice; Sec. 102: consideration of environmental impacts. Together these sections say we must consider the impacts of our actions on diversity.

Endangered Species Act: Sec. 2 (b) Purposes. The purposes of this Act are to provide a means whereby the ecosystems upon which endangered species and threatened species may be conserved, to provide a program for the conservation for such endangered species and threatened species. Policy: it is further declared to be the policy of Congress that all Federal departments and agencies shall seek to conserve endangered and threatened species and shall use their authorities in furtherance of the purposes of the Act. The effects of the conservation of individual species have been known to relate directly to diversity for a long time. For example, the definition in the regulations speaks to different species. And, for more than 15 years it has been recognized that species richness (the number of different species) has been a critical parameter in several mathematical measures of diversity, e.g. the Shannon-Wiener function.

National Forest Management Act: This law tells us we must provide for diversity within the overall context of multiple-use objectives. It is this relationship that is most often not displayed and explained adequately in the Forest Plans I have read or reviewed. The appeal of the Nicolet Forest Land and Resource Management Plan resulted in a decision that has become our current position on diversity in forest planning. A review of that decision provides the basis upon which we need to be building and the National Forest Management Act (NFMA), as it relates to diversity in land management planning.

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Background on Diversity in Forest Planning

The National Forest Management Act of 1976 provides statutory direction for managing the National Forest System to provide for diversity of plant and animal communities. Section 6(g)(3)(B) of the NFMA, the diversity provision, states:

> "The [planning] regulations shall include, but not be limited to . . . (3) specifying guidelines for land management plans developed to achieve the goals of the [RPA] Program which . . . (B) provide for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet overall multiple-use objectives of a land management plan adopted pursuant to this section, provide, where appropriate, to the degree practicable, for steps to be taken to preserve the diversity of tree species similar to that existing in the region controlled by the plan."

The legislative history of the NFMA indicates that the two basic parts of the diversity provision resulted from concerns about large scale forest type conversions and the associated effects on plants and wildlife communities. (See specifically: 1) April 27, 1976, Senate Committee on Agriculture and Forestry and Senate Committee on Interior and Insular Affairs, Transcript of Proceedings, S. 3091, As Amended, pp. 51-54, 2) H.R. Report No. 1478, part 1, 94th Congress, Second Session, p. 31, and 3) Senate Report No. 1335, 94th Congress, Second Session, pp. 26-27).

The diversity provision of the NFMA must be read in context with the other requirements of the law. Section 6 of the NFMA requires that each Forest Plan provide, in a single set of documents, the overall management direction and guidelines for management of the applicable National Forest for a period of 10-15 years (16 U.S.C. 1604(f)). The NFMA requires that the Forest Service apply a systematic, interdisciplinary approach to achieve integrated consideration of physical, biological, economic, and other sciences in the preparation and implementation of Forest Plans (16 U.S.C. 1604(b)). The Forest Plan is to ensure coordination of all multiple uses: outdoor recreation, range, timber, watershed, wildlife and fish, and wilderness (16 U.S.C. 1604(e)). These and the other provisions of the NFMA must all be read together to promulgate and maintain a land and resource management plan. Diversity is one of a multitude of factors that must be considered in developing Forest Plans that "provide for multiple use and sustained yield of the products and services obtained (from the applicable National Forest) in accordance with the Multiple-Use Sustained-Yield Act of 1960" (16 U.S.C. 1604(e)(1)).

To ensure an adequate consideration of diversity consistent with section 6(g)(3)(B), the implementing regulations (36 CFR 219) address diversity at several points. First, the regulations provide a definition of diversity to guide land and resource management planning:

> 36 CFR 219.3 *Definitions and terminology.* For purposes of this subpart the following terms, respectively, shall mean: . . . Diversity: The distribution and abundance of different plant and animal communities and species within the area covered by a land and resource management plan.

Other sections of the regulations where the term "diversity" is used are:

> 36 CFR 219.26 *Diversity.* Forest planning shall provide for diversity of plant and animal communities and tree species consistent with the overall multiple-use objectives of the planning area. Such diversity shall be considered throughout the planning process. Inventories shall include quantitative data making possible the evaluation of diversity in terms of its prior and present condition. For each planning alternative, the interdisciplinary team shall consider how diversity will be affected by various mixes of resource outputs and uses, including proposed management practices.

> 36 CFR 219.27 *Management Requirements.* (a) Resource Protection: All management prescriptions shall-- (5) Provide for and maintain diversity of plant and animal communities to meet overall multiple use objectives, as provided in paragraph (g) of this section;

Diversity: Management prescriptions, where appropriate and to the extent practicable, shall preserve and enhance the diversity of plant and animal communities, including endemic and desirable naturalized plant and animal species, so that it is at least as great as that which would be expected in a natural forest and the diversity of tree species similar to that existing in the planning area. Reductions in diversity of plant and animal communities and tree species from that which would be expected in a natural forest, or from that similar to the existing diversity in the planning area, may be prescribed only where needed to meet overall multiple use objectives. Planned type conversion shall be justified by an analysis showing biological, economic, social, and environmental design consequences, and the relations of such conversions to the process of natural change.

Regulation 36 CFR 219.26 establishes minimum requirements for integration of diversity throughout the forest planning process, and 36 CFR 219.27 establishes requirements for resource protection and enhancement of diversity.

These requirements direct that for the planning area (the area of the National Forest System covered by a Forest Plan): 1) information is to be collected, 2) diversity is to be considered and evaluated, 3) management prescriptions are to provide for diversity (where appropriate and to the extent practicable), and 4) reductions in diversity--including type conversions--are to be justified in terms of overall multiple-use objectives.

The Forest Plan establishes the requirements, vision, and expectations for the diversity of plant and animal communities that best meet overall multiple-use goals and objectives for the planning area. The Forest Plan guides project implementation through Forest-wide standards and management area prescriptions. Activities and projects must be consistent with the Forest Plan.

Monitoring and evaluation of the collective effects of all projects and activities, including the addition of new information, will determine if Forest-wide requirements are being met and whether adjustments in the Forest Plan are required to meet overall multiple-use objectives.

Evaluating Diversity - Regulations

The regulations call for diversity to be considered throughout the planning process (36 CFR 219.26). The diversity provided by a Forest Plan is evaluated by determining how that Plan has considered the distribution and abundance of plant and animal species and communities to meet its overall multiple-use objectives. Several of these objectives are clarified by 36 CFR 219. Specifically, forest planning shall provide that:

- Management direction contributes to recovery and conservation of federally listed threatened or endangered species (Endangered Species Act, 36 CFR 219.19).

- Management of habitat provides for the maintenance of viable populations of existing native and desired nonnative, wildlife, fish (36 CFR 219.19), and plant species (USDA Regulation 9500-4) well distributed throughout their current geographic range within the National Forest System. As interpreted by the Secretary, this means that LRMP's should identify or be amended to identify known sensitive species and provide Forest Standards and Guidelines that ensure conservation when an activity or project is proposed that would affect the habitat of a sensitive species (USDA Decision on Review of Administrative Appeals of the Beaverhead NF LRMP by John L. Evans, August 17, 1989).

- Management of plant and animal communities identified in Regional Guides, or Forest Plans as issues that warrant special measures achieves overall multiple-use objectives (36 CFR 219.8, 219.12(b), 219.27).

- Management direction includes objectives for selected management indicator species (36 CFR 219.19). The Forest Plan should specify for plant and animal species and/or communities identified as major Forest Plan issues or management indicators:

- Standards and guidelines for protection, viability, recovery or restoration as appropriate to meet overall multiple-use objectives (36 CFR 219.27);

- The expected future conditions in terms of distribution and abundance of populations or habitats to meet overall multiple-use objectives (36 CFR 219.11, 219.26);

- The schedule for monitoring and evaluation of standards, guidelines, and objectives for plant and animal species and communities (36 CFR 219.27); and

- A discussion of any proposed type conversions. If any conversion results in a reduction in diversity, explanation must be provided to explain why the conversion is necessary to achieve multiple use objectives (36 CFR 219.27).

Evaluating Diversity - Framework

This position/framework of diversity has some inherent problems in implementing the existing statutory goals and regulations:

Ambiguity - There is no scientific consensus on the definition, scope (alpha vs. gamma), or measurable indicators (indices, MIS, ?), etc. The laws and regulations themselves are ambiguous - what exactly does "consider" and "provide for" mean in measurable terms?

Standards - How much diversity is enough; what scales are appropriate to goals and objectives?

Data - Our inventories and assessment methods for determining status, trends, and future states of diversity are inadequate or non-existent.

Precedence - There is confusion over what comes first, diversity or other multiple-use objectives.

Well, how do we resolve these problems? Through appeals? I hold that using the appeal process is not the best way as it is not a forward-looking or proactive approach. As I said earlier, appeals and lawsuits only tell you if what you did in the past was right or wrong; therefore, we shouldn't be managing for diversity because we are directed to in a decision letter, rather because it is the right thing to do.

So, what are the priorities for maintaining biological diversity that are tied to the relevant laws and regulations and highlighted in the framework resulting from the Nicolet Decision? And how do we accomplish them?

The highest priority is to save endangered species. This is tied to the ESA and can be satisfied by such actions as:

- complying with Fish and Wildlife Service recovery plans and biological opinions.

- enhancing population numbers.

- expanding geographical ranges.

- increasing protection from adverse human influences.

The next priority is to keep sensitive species from sliding toward endangerment. This is tied to 36 CFR 219.19 and USDA Regulation 9500-4. This can be done by updating our lists regularly and periodically with our partners and other Federal and State agencies. We need to provide consistent direction for the use of biological evaluations.

We need to perpetuate biological communities that may be jeopardized by our planned activities; e.g., old-growth forests, riparian areas, wetlands, etc. This can be accomplished by using such devices as RNA's, wilderness, stream-side management zones, special management areas, management standards and prescriptions in managed portions of NF's.

We need to provide for elements of structural diversity that may otherwise be compromised; e.g., snags, fallen trees, landscape linkages, corridors, habitat mosaic. These can be accomplished through management standards and guidelines.

Our next priority should be to prescribe management practices that minimize disturbances to natural processes. However, we must recognize that some disturbance is inevitable to meet human resource needs for fish, wildlife, timber, livestock, recreation, minerals, etc..

Finally, we need to establish sound processes to improve our inventories, monitoring and evaluations that ascertain if we are meeting our objectives.

Each of these points has been raised as an issue in an appeal or litigation of a Forest Plan over the requirement for diversity under NFMA. Presently, Forest Plans are still working toward consistency and sufficiency on this approach. However, this approach is more limited than what we now consider under the concept of biological diversity. We need to build on the good parts and not discard it in hopes of finding an altogether new one. Well, how?

First, review the above section on evaluating diversity in Forest Plans. Our current position on diversity, as that section describes, establishes no additional requirements beyond those identified for MIS, population viability of sensitive species, recovery and conservation of T & E species, and protection of special habitats. This is our current position.

Now, how do we build on our current approach/position? This is where appeals and lawsuits do not give us much direction and advice. They may tell us how to fix what is wrong, but only relative to the current laws/regulations and policy. If nothing else, the Nicolet decision put all the regulations that deal with diversity into a single framework; however, these parts have been with us for well over 10 years! We need to do it!!

In building a better approach, we will also be building better plans and proposals that will avoid or withstand appeals and challenges much better. We must start addressing and describing our proposed actions on larger scales. The larger the area, the greater its potential for sustaining biological diversity. The smaller the area, the more limited are its potential contributions to biological diversity. Thus, scale, from sites to watersheds to Forests to Regions is a crucial issue in addressing goals or evaluating effects on biological diversity. Planning at each geographic scale should provide for the biological diversity that best meets overall goals and objectives.

To better evaluate the effects of alternatives on biological diversity, field indicators should be selected considering the following categories:

- all federally listed T&E species
- Forest Service sensitive species
- key elements of structural and functional diversity relevant to the area
- species or communities managed for commercial, subsistence, or recreational purposes
- species or biological communities thought to be valid indicators of the overall conditions and trends of ecosystems.

Effects on the field indicators within each alternative should be described at reasonable future dates; e.g., 5, 10, 25, 50, and 100 years.

Conclusion

We need to read decisions of appeals dealing with biological diversity so we are aware of the basis others are being challenged. Perhaps we need some kind of diversity network to plug them into, so all levels (especially Districts) are tied in. In addition we must be sure our decisions are well-founded in the most current and robust science that will stand up to the solid, scientifically based appeals we are getting. One way to achieve this is through continuing education. We need to acknowledge in our decision documents that we are purposefully managing for increased biological diversity.

Perhaps we need to make biological diversity the primary objective of all our planning and decision documents. Its already in the laws and regulations, we have a framework, multiple-use outputs are dependent on it, now we need a philosophical shift from the current resource-oriented paradigm "manage for specific resource uses" to a more ecosystem-oriented paradigm "manage to sustain diverse and productive ecosystems for all their values and uses.

BIODIVERSITY

Bob Naumann
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Northern Region

How biodiversity relates to the Northern Region. My task here is to narrow this broad topic to how biodiversity relates to Forest Management in the Northern Region. Easier said than done.

The concept of biodiversity adds an important but difficult-to-understand objective to an already long list of objectives. I think most of us have only a foggy notion of how to apply the concept of biodiversity in our management efforts. Biodiversity is an attribute of the forest and dependent wildlife species--not a program or a slogan. It is related to ecological stability, and perpetuation of productivity, regardless of the product. It is an insurance policy that nature takes out for the future. Through our management efforts we want to maintain that insurance policy in force.

Management is a term that means different things to different people depending upon their point of view. To many people, management as applied by the Forest Service has a bad connotation. To most of us in the Forest Service, management is viewed as an act of stewardship. How do we manage forests? What do we really do to forests when the talking and planning harangue is finished? What we actually do to manage is influence the structure, composition and growth of forests to meet objectives that we have set. Influence is the correct word to describe our management. We would be foolish to think that we could actually control the forest. By influencing the diversity of the forest we influence the diversity of its wildlife populations.

Influence to meet objectives. How do we influence to meet a biodiversity objective?

As with any other desired effect we must first understand, and then be able to describe a forest that is diverse enough. The basis for this understanding is the ecology of forests in the Northern Rockies - their form and composition and the processes that result in growth and mortality of these complex biological communities. The description itself is in terms of tree sizes, densities, species compositions, amount of dead material, size and juxtaposition of plant communities and so on.

Our management efforts are applied to stands, but forests are aggregates of many stands. And so our understanding and description of diversity must extend to the forest landscape. Actions taken at the stand level will influence the whole. Sometimes, what is best for a given stand may not be best for the aggregate.

How do we go about this management? There are several means to purposefully effect change in a forest. Fire or grazing can bring about changes. Fire may not be as viable as previously thought because of air quality considerations. Tree cutting and subsequent renewal are the means most often used. These activities are guided by the application of silviculture. Simply put, silviculture is the art and science of growing trees in a forest setting. As an aside silviculture does not mean timber management except as timber is one of the many resources to be produced from our management efforts.

We are now concerned about new forestry or New Perspectives. There is nothing new about the principles of silviculture - the change is in the form of the forest desired to fit a New Perspective of forest management. Silviculture is still the means to the desired end.

So lets look at some elements of silvicultural practice and consider how they may be used to meet a management objective of biodiversity.

Regeneration Systems

Regeneration systems are usually classified as even or uneven-aged. This is primarily a device

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to facilitate regulation of timber crops. Since we will continue to regulate yields of forest products from Federal lands we will continue to distinguish between even and uneven-aged systems.

But--the key to which system to use should not be based upon politics but rather upon the successional patterns inherent in the ecosystem being managed. In other words the way we manage forests over time must, first and last, make good biological sense.

Where forests are naturally of a regular uneven-aged form, uneven-aged silvicultural systems can be used to meet resource and biodiversity objectives. However, it is difficult to find this kind of regularity in native stands. The application of uneven-aged management depends upon maintenance of a J-shaped diameter distribution that is regulated by a "Q" factor. While it has been argued that the J-shaped curve mimics the natural 3/2 thinning rule, the biometrics of this system get in the way of the biology of the system. I am not speaking against uneven-aged management, but rather speaking for observing and trying to understand how forest systems really work in the Northern Rockies.

A large proportion of forests in the Northern Rockies are even-aged in form and function. Even-aged silvicultural systems can be adapted to achieve diversity goals that are consistent with ecosystem processes.

The bottom line for choosing a silvicultural system is this: When we manage outside the bounds of successional patterns established through thousands of years of adaptation, we are unnecessarily challenging the inherent stability and risking the diversity of Northern Rocky Mountain forests.

<u>Reforestation</u>

Renewing the forest is a key activity that is easily de-emphasized when management practices rely more heavily on partial cutting techniques. Northern Rocky Mountain forests in their natural state were dominated by seral species. This was a characteristic of their diversity. Most older stands are composed of long-lived seral species. Don't forget that some of the mid-tolerant species are seral on some sites. Seral species are generally longer-lived, less susceptible to insects and disease, and are more resistant to physical influences like wind and fire.

To insure that forests in the Northern Rockies retain an appropriate seral component, prompt regeneration measures like site preparation and planting are often required. We will continue to be actively engaged in reforestation.

<u>Stand Culture</u>

Natural processes will maintain diversity if time and space are not constrained. Both of these factors are limited in the management plans of the 1990s. We are limited by 40 acre openings, rotation lengths and the need to provide a mix of benefits on areas that are smaller when compared to the natural scheme of things. This means that we cannot regenerate an area and just walk away for the next 100 years. Thinnings, improvement cuts, cleanings weedings, sanitation and salvage are all tricks of the trade to keep things moving in approximately the right direction on a desired time scale. These cultural methods contribute to forest health, vigor and subsequent future options.

<u>Forest Health</u>

Another frequently overlooked consideration is forest health. In the naturally diverse forest, the organisms we characterize as problems played a role in forest succession. Through many years of fire control and naive cutting practices we have drastically modified the diversity of forests in the Northern Rockies. Insects and fungal organisms now respond to these changed forests in ways that make achieving and maintaining diversity difficult if not impossible. We have lost much of the inherent stability that was found in the native forest. Our forests are not healthy.

To be specific, major insect problems in this Region are Mountain Pine Beetle and Western Spruce Budworm. Root diseases are probably the single most troublesome fungi. Mistletoe on most of the conifer species is a significant parasite. White pine blister rust is an intro-

duced disease that presents special problems in native forest ecosystems.

The implication for management seems clear. Whatever we do must be consistent with maintaining a healthy forest. In too many cases we are involved in a rehabilitation situation. Lets recognize in developing management alternatives that silviculturally, we know how to bring most of these pest organisms to a level commensurate with what we might expect in a naturally diverse forest. Politically, we have fewer options.

Landscape Problems

A challenge to management in the Northern Rockies is the need to scale down activities to fit a smaller species and shorter time frames than those resulting from natural processes. As we move to the landscape level, we need to recognize that we are not able to deal in all situations with whole ecosystems. Many times we are managing the higher elevation fringe of a total landscape dominated by human use on private lands. Sometimes this use is interspersed with National forest lands along ownership lines that have nothing to do with the ecosystem.

Even in the most ideal situations it is difficult to deal with landscapes. The concept is valid-the application is yet to be tried and evaluated. We can think about stands one at a time. We can have a feel for how they may develop even over hundreds of years. We do not yet have the same capability for landscapes. The solution will likely be sophisticated computer programs that can simultaneously manipulate large groups of stands over large areas in different ways to achieve different effects. This kind of senario is on the edge of human comprehension. Can anyone of us form a mental image of a changing landscape over a long time frame, much less form an opinion of the effect of those changes? Think of hundreds of interconnected stands in any stages of succession and each developing at its own rate of growth, each influenced by insects and disease. Managers need to be wary of computer solutions to which they cannot apply some professional intuition.

Summary

Before we can manage for biodiversity we must define what form and character that biodiversity will take. That definition must be consistent with the processes that govern forest succession in the Northern Rockies. For biodiversity over the long run we can do no better than this. We must account for the perception by people in and outside of the agency of what the forest should look like. Good biology, including adequate biodiversity, will not always be a popular outcome of management. As responsible managers we should not get trapped into practicing bad biology. So we need to take the fog factor out of this topic and be very sure of what we want and why we want it on specific areas of the National forests to meet our objective of biodiversity.

CHARACTERIZATION OF BIODIVERSITY IN THE NORTHERN REGION

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Abstract

This paper provides a broad level review of concepts related to biodiversity, general characterization of the community/ecosystem and landscape levels of biodiversity, and significant attributes relative to biodiversity for the Northern Region. The National Forests and Grasslands in the Northern Region provide an important resource relative to biodiversity, not only from a National perspective, but from a North American and World perspective. Based on the review of the biodiversity resource and its importance to production of resource values and uses, and potential importance in agricultural genetics and biomedical development, it is a must that we move ahead in learning how to manage these systems and maintain biodiversity.

Introduction and Concepts

The purpose of this paper is to provide an overview of the diversity of communities, ecosystems, and landscapes in the Northern Region, and their value to biodiversity. Some basic ecological concepts are reviewed to provide a basis for discussion.

There are a variety of definitions for biodiversity. A fairly global definition is "the variety of the world's organisms, including their genetic diversity and the assemblages they form (Reid and Miller 1989). The Office of Technology and Assessment (1987) provided the definition "the variety and variability among living organisms and the ecological complexes in which they the landscape or ecosystem levels, which are very important to the concept of conserving biodiversity. A more thorough definition would be "the variety of communities, species, and genes, and their interactions with ecological processes and functions, within ecosystems and across landscapes. The concept of an ecosystem is an important aspect to understanding biodiversity. An ecosystem "is the sum of the plant community, animal community, and physical environment in a particular region or habitat (Barbour et al. 1980). A community, whether plant, animal, or plant/animal is "any group of organisms interacting among themselves (Daubenmire 1978)." An important concept to understand from both these definitions is that the scale of both a community (which is the biotic component) or an ecosystem (which is both the biotic and environmental components) can vary depending on the subject of the discussion or analysis. For instance, the vertebrate community may be used to generally refer to interaction of vertebrate animal species. At a much finer level, the communities inhabited by pine marten (Martes americana) and dominated by lodgepole pine (Pinus contorta) in the overstory and menziesia (Menziesia ferruginea) in the understory, may be used to discuss marten populations and associated habitats.

Ecosystems also vary in scale and bring in the concept of site conditions and potential community. At a fine scale we can assess ecosystems inhabited by pine marten, dominated by lodgepole pine/menziesia on north aspects with moderately developed loamy soils, developed in an ash cap over granitic parent materials, where the potential community is subalpine fir (Abies lasiocarpa)/menziesia. This can even be further refined to evaluate a specific piece of land area. An ecosystem can also be broad when taken in the context of evaluating all the environments that can support lodgepole pine at some point during succession. At a very broad level we can assess grassland or forest communities and ecosystems.

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A landscape is "a heterogeneous land area composed of a cluster of interacting ecosystems that are repeated in similar form throughout" (Forman and Godrun 1986). Landscapes also vary in scale. A fine scale landscape would be a north aspect about 40 acres in size where there is a repeating pattern of lodgepole pine/pinegrass (Calamagrostis rubescens) on well drained slopes with small areas of spruce (Picea engelmannii)/horsetail (Equisetum spp.) in concave seep areas. A moderate scale landscape would be a watershed of about 60,000 acres with a repeating pattern of Douglas-fir (Pseudotsuga menziesii) /bunchgrass on the south aspects, Drummond's willow (Salix drummondiana)/sedge (Carex spp.) in the riparian bottoms, lodgepole/ pinegrass on the north aspects, and whitebark pine (Pinus albicaulis)-subalpine fir/ whortleberry (Vaccinium scoparium) on high elevation sites. A coarser scale assessment may look at the general zonation of valley-montane- subalpine-alpine in the Pioneer, Beaverhead, Ruby Ranges/Valleys. An even more general assessment may be done by looking at variation in general vegetation types, topography, and other features of the northern Rocky Mountains relative to travel zones for wide ranging predators.

An important difference between the concept of a landscape and community/ecosystem is that the terms community and ecosystem are used for discussing or evaluating a "kind of situation" of interest, and emphasizes the system within the community or ecosystem. This contrasts with the concept of landscape, which is used for discussing or evaluating an area that contains a repeating group of different "kinds of ecosystems" and emphasizes the system conditions and connections across all units of the landscape. An additional important aspect of the landscape concept is evaluating connections to adjacent landscapes. This is especially important when evaluating animal species, such as grizzly bear (Ursus horribilis), elk (Cervus canadensis), bald eagle (Haliaeetus leucocephalus) or cutthroat trout (Salmo clarkii), that have a home range that encompasses a group of adjacent landscapes.

An important concept relative to biodiversity, that is often overlooked, is the dynamics of communities /ecosystems and landscapes through time. It is the dynamic changes through time that eventually result in adaptation or speciation, or loss of species. The dynamics and connections of communities through successional time is as important to biodiversity as the dynamics and connections of communities across landscapes. These successional changes can happen in relative short successional time as a result of community response to disturbance. This type of succession is considered secondary succession. Successional change can also happen as a result of a change in physical environment, such as climate or soils, or as a result of an introduction of biota previously unavailable to the area. These biota are typically considered exotics. Succession that is a result of changes in the primary site factors or regionally available biota is considered primary succession.

Ecosystems and Landscapes of the Northern Region

The Northern Region contains landscapes of the southern northern Rockies, northern middle Rockies, northern Great Plains, and Central Lowland physiographic provinces (Hunt 1974). The primary coarse scale factor affecting ecosystems of the Northern Region is the shift from an marine influenced mountain/valley climate on the western side of the Rockies to a continentally influenced mountain/valley climate on the east side of the Rockies to a continental plains climate in the northern Great Plains. On the western edge of the Region, from the Spokane and Snake Rivers east to the Swan and Bitterroot Ranges the climate is heavily influenced by storms from the Pacific Ocean. The majority of precipitation comes in the winter ranging from 12 to 14 inches in the valleys to 50 to 60 inches at higher elevations. Throughout most of this area there is a relatively high amount of cloudy days, ranging from 120 to 150, with most occurring during the winter and spring months (Trewartha and Horn 1980). This relatively high amount of cloudiness appears to preclude big sagebrush (Artemisia tridentata) species and varieties from dominating in the dry valleys and south aspect mountain slopes. Nonforest upland vegetation is typically dominated by cool season

bunchgrasses, such as bluebunch wheatgrass (Agropyron spicatum), Idaho fescue (Festuca idahoensis), and rough fescue (Festuca scabrella). Upland forests at low elevations are typically dominated by ponderosa pine (Pinus ponderosa) and Douglas-fir. Forests at moderate elevations in moist environments are typified by western redcedar (Thuja plicata) and western hemlock (Tsuga heterophylla). Forests at moderate elevations in dryer environments at moderate elevations are typified by grand fir (Abies grandis), western larch (Larix occidentalis), Douglas-fir, lodgepole pine, and spruce. Forests at high elevations are characterized by dominance of subalpine fir, mountain hemlock (Tsuga mertensiana), alpine larch (Larix lyallii), and whitebark pine.

From the Swan and Bitterroot Ranges east to the Continental Divide there is a transition from the strongly marine influenced mountain climate to the west to the continental mountain climate that occurs east of the Continental Divide. A higher amount of precipitation comes in the spring and summer in this area and ranges from 12 to 14 inches in the valleys to 40 to 50 inches in the mountains. Nonforest upland vegetation in the valleys and on south aspect dry mountain slopes, is typically dominated by sagebrush, rough fescue, Idaho fescue, bluebunch wheatgrass, or bitterbrush (Purshia tridentata) depending on site conditions. Ponderosa pine or Douglas-fir typically dominate upland forest sites at lower elevations and south aspects at moderate elevations. Lodgepole pine and spruce typically dominate cooler, moist north aspect slopes at moderate elevations. High elevation upland forests are typically dominated by subalpine fir and whitebark pine, with minor amounts of alpine larch. High elevation ridges and south facing ridge shoulders are often not forested and are dominated by Idaho fescue and elk sedge (Carex geyerii).

From the Continental Divide east to the transition to the Plains, the area has a continental mountain climate. Much of the precipitation comes during the spring and summer months and ranges from 10 to 12 inches in the valleys to 25 to 35 inches in the mountains. The number of cloudy days is less than the area to the west, averaging 100 to 120 days (Trewartha and Horn 1980). Nonforest upland vegetation in the valleys and on south aspect dry mountain slopes is typically dominated by sagebrush. Some areas, with special soil conditions, are dominated by other grass or shrub species. Douglas-fir or ponderosa pine typically dominate upland forest sites on south aspects in the mountains. Lodgepole pine typically dominates more mesic sites at moderate elevations. In many of the high elevation valleys there is a direct transition from nonforest vegetation to lodgepole pine. High elevation sites are typically dominated by whitebark pine and subalpine fir. Many south aspect mountain slopes at moderate and high elevations are dominated by nonforest vegetation. These are usually sagebrush or bunchgrass species at moderate elevations and tufted hairgrass (Deschampsia caespitosa) and sedge species at higher elevations.

On the eastern front of the Rockies there is a strong continental climate influence, with an added factor of steady and regular wind events. This strongly influences effective moisture by desiccating the soil surface. In these windy environments the vegetation has also been structurally affected, making trees less competitive than shrubs and grasses. Historically, the wind events have also interacted with fire, causing frequent, widespread fire events.

From the Rocky Mountain front there is a fairly abrupt change to the Plains vegetation. This climate is a continental climate with precipitation on the western edge ranging from 8 to 10 inches increasing to the eastern edge of the Plains to 18 to 20 inches. Much of the precipitation occurs during the spring and summer with an increasing amount coming during the summer further to the east. Upland grasslands are dominated by western wheatgrass (Agropyron smithii), needle and thread (Stipa comata), and blue grama (Bouteloua gracilis) in the dryer western parts of the Great Plains, with a transition to little bluestem (Andropogon scoparius) and big bluestem (Andropogon gerardi) to the east.

Additional factors, other than climate that cause major differences in ecosystems, are the large variation in mountain, valley, and plains landforms and soils. There is a transition from rugged mountain and valley topography

in the western portion of the Region shifting to plains topography with scattered isolated badlands and mountains in the eastern portion of the Region. In the western portion of the Region valleys are relatively narrow with a transition to wide valleys in the Continental Divide area. Soils are highly variable with volcanic ash caps causing a major influence in the western part of the Region. The effects of continental ice sheet glaciation are extensive along the northern section of the Region and mountain glaciation has been extensive at elevations above 6000 feet in the mountainous portion of the Region. There are also major differences in parent materials ranging from limestone to granitic to metamorphic to sedimentary.

Attributes of Biodiversity in the Northern Region

They are some key attributes that make the Northern Region unique in its role of contributing to biodiversity. One of the primary factors is the geographic placement of the Region relative to the transition from the marine influenced climates to the continental climate of the Great Plains. This provides for variation extending from the cedar-hemlock forest ecosystems of northern Idaho and northwestern Montana to the tall grass prairie ecosystems on the eastern edge of the Great Plains in North Dakota. A variety of ecosystems occur along this transition allowing for a large number of flora and fauna. Along with large species and genetic variety, resulting from the variety of ecosystems, there is also a great variety in landscapes and connections of cycles, processes, functions, and species through these systems.

National Forests and Grasslands of the Northern Region contain a relatively high portion of the Rocky Mountains, badlands, and isolated plains mountain environments. These landscapes contain steep environmental gradients and sharp ecotones that result in a high diversity of organisms and ecosystems within relatively small areas. This diversity of ecosystems, communities, and species across relatively small landscape areas not only provides for a richness of biotic diversity, but a richness of system linkages and processes. Because of this richness, these lands are extremely important reservoirs for genetic material and often maintain remnant populations of species that have been made rare through agricultural development in the valleys and plains.

Wetland, riparian, aquatic, and flyway environments have primary importance in the landscape matrix relative to community productivity, corridors for movement, the hydrologic cycle, and system connections. The Northern Region has extensive riparian and wetland environments that provide a rich aquatic habitat and flyways for many migratory bird species. Many riparian and wetland ecosystems, especially those typical of valley and plains environments, are becoming rare. The National Forests and Grasslands provide an important component of these types of ecosystems along with critical watershed and headwater riparian and wetland ecosystems.

One of the keystone processes in the northern Rockies and Great Plains is fire and its relationship to dependent species and communities. Fire has played a key role in all of the upland forested and nonforested ecosystems and in most of the riparian ecosystems (Arno 1980; Fischer and Bradley 1987; Fischer and Clayton 1983; Crane and Fischer 1986; Gruell 1983). The type of fire and variation in fire intervals differs greatly depending on the ecosystem and the geographic area. Many species have developed fire related adaptations, such as cone serotiny in lodgepole pine and thick fire resistant bark such as in ponderosa pine and Douglas-fir. Since most of the ecosystems in the Northern Region accumulate biomass at a faster rate than it can decay, fire is the major process for recycling of stored nutrients and energy. Fire is the dominant natural process for initiating secondary succession and is also the major influence in landscape patterns for upland systems.

Many of the upland ecosystems in the northern Rockies are stressed by inadequate moisture and/or nutrients. This leads to fairly intense within and between species competition. As a result there are many insects and diseases that reduce the vigor or cause mortality in stressed individual plants. Fire has typically played an interactive role by thinning trees, thus increasing their vigor and reducing susceptibility to insects, such as bark beetles and spruce budworm.

Due to the wide array of site conditions, processes such as fire, and stresses such as insects and disease, most plants and some animal species have developed a wide genetic base for adaptation. Many species, such as shrubby cinquefoil (Potentilla fruticosa), Douglas-fir or sagebrush have adapted specific ecotypes to survive in varying environments, competitive stresses, or processes. Aspen (Populus tremuloides) has adapted to survive under various site conditions, to survive weather extremes, and to resprout after herbivory or fire.

In the northern Rockies and Great Plains many of the species and communities are at the edge of their range. This is caused by the sharp transitions from mountain to plains environments and from marine influenced to continental climates. At the edge of their range many species have developed specific ecotypes to better survive the environmental variation. These ecotypes are important for the species survival in the face of long or short-term climatic change.

In comparison to other physiographic regions the northern Rockies and Great Plains have a relatively low number of rare species. This is primarily related to the fairly high component of natural habitats that exist in the area. If agricultural development continues in the Great Plains and these rangeland habitats continue to decline, the number of rare species will increase. In the northern Rockies the major habitats that are threatened are the valleys and foothills. If urban development, intensive agriculture, and roading continue in these lands the number of rare species will increase.

Another factor affecting the overall status of natural forest and rangeland communities is the effect of exotic species. Introduction of exotic species, whether they be economically undesirable, such as leafy spurge (Euphorbia esula), or desirable, such as timothy (Phleum pratense), are generally a detriment to native species and connections between native flora and fauna. Exotic species have usually been introduced without native insect and disease parasites and are therefore much more competitive than our native species. Consequently, they can usually out compete the native species and upset delicate connections between flora and fauna and in the nutrient cycle. To date we are fairly lucky in the northern Rockies and Great Plains in comparison to physiographic regions to the south and east. Although we have some very aggressive exotics in rangelands they have not spread through a high percentage of the rangelands and we have few exotics in the forest environments.

From an economic sense, we have many native species in the northern Rockies and Great Plains that have high value. In the forests we have a relatively wide array of species that provide valuable habitats and wood products. A mix of tree species can usually be managed that represent natural community composition and are resistant to insect and disease mortality. On rangelands the natural composition of native species is highly productive and provides nutritional forage. With proper range management these communities can sustain high productivity and maintain a stable and desirable composition. The value of our native species for agricultural genetics and biomedical developments has been essentially unstudied to date. With their wide genetic base and adaptations to disturbance, insects, and disease it is highly likely that many of our species of flora or fauna, or one or more of their ecotypes, will provide valuable resources for improvement of agricultural crop species and for medicinal treatments.

Possibly one of the greatest assets the Northern Region has to offer to biodiversity is the high percentage of National Forest and Grasslands that is in some form of natural management area. These management areas include wilderness, wild and scenic rivers, research natural areas, special interest areas, and semi-primitive areas. They range from large areas, such as the Bob Marshall Wilderness Complex, to medium sized areas such as the Allan Mountain Roadless Area, to small areas, such as the Plant Creek Research Natural Area. Each area has its own and important role to play in providing a place where native species and natural processes can function in a somewhat natural role.

Summary

This paper has reviewed some of the basic characteristics relative to community/ecosystem and landscape biodiversity in the Northern Region. It is apparent that the complexity and variability of these systems is high. In order to manage these systems for production of an array of resource products and values and maintain biodiversity we must understand the functions and processes of these ecosystems. It is fairly obvious that it does us little good to recognize when we have almost lost a species or disrupted an ecosystem function or process. If we wait until after the fact, the investment to recover the species or to reestablish the function or process is high, and the probability of recovery is poor. The answer to good management and prevention of loss is an understanding of the ecological relationships. We can achieve this through characterization and development of interpretations of our communities/ecosystems and the landscapes where they occur.

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HOW LAND MANAGEMENT AFFECTS BIODIVERSITY

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In the 10 years I have been an ecologist on the Willamette and Siuslaw National Forests, I have seen major changes in the philosophy of land management. When I started in 1980, the rallying cry on the Willamette National Forest was a billion or bust. The Willamette National Forest was close to harvesting a billion board feet a year. Now, in the recently completed Forest Plan, old-growth is a key issue and new perspectives and biological diversity are incorporated into the standards and guidelines and into the monitoring plan. We have moved a fair distance, not as far as I would like but a fair distance, toward managing in a more ecologically sensitive fashion.

I would like to share my rationale of managing for biodiversity from a Forest Plan implementation perspective, starting with my own personal perspective on the importance of biological diversity. The human species is an experiment in survival just as is any other species. We are a classic experiment in natural selection. Whether or not we can survive over the long-term will depend on our ability to co-exist with the rest of the natural world, which supports us.

Our knowledge of how ecosystems work has grown by leaps and bounds in the past 20 years. We know, for example, forest ecosystems developed with large amounts of structural complexity in live trees, snags, and downed wood. These elements of complexity, which we typically simplify, play important roles in an ecosystem--nutrient cycling, animal habitat, soil productivity, stream and soil stability, to mention just a few.

Inspite of our advances in understanding ecosystems and the way they function, we still understand very little. For example, 10 years ago we vastly underappreciated the below-ground portion of the ecosystem. Recent work indicates that even on some of our most productive sites, half of the total energy fixed by the stand goes below the ground. We would be wise to tread lightly when manipulating such important and complex ecosystems.

The productivity of the land that we see and enjoy is a reflection of the complexity and functioning of the ecosystem over thousands of years. Nearly all the wood produced by west-coast forests has decomposed on-site over the last ten thousand years. Natural disturbance rarely removes very much of the wood. Most of it returns to the soil.

On the other hand, humans' demands on natural resources are huge and increasing. I would argue that there is not a place on the face of the globe unaltered by human activities. We in the Forest Service are intermediaries between those demands and the ability of the natural world to provide. We are the front line. We are where society makes its impact on the natural world of the National Forests. My personal goal is to maintain the long-term survival of natural ecosystems and allow the extraction of some level of commodities. Commodity production is going to happen whether I like it or not.

I think National Forest management causes some long-term habitat destruction. By destruction, I mean modification where the system probably won't recover for a century or more. The most obvious of these are activities which severely impact the soil. Major roads, administrative sites, severe compaction from equipment, severe erosion, and losses of nutrients from excessive prescribed fire intensity are good examples. The vast majority of our impacts, however, are more subtle and mostly related to reducing biological diversity through habitat alteration. The vast majority of those impacts are the result of simplification which occurs both at the stand and landscape levels. We were brought up with, and most of

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us like, the garden view of the world. We like our gardens in neat rows of carefully controlled plants which fully occupy the growing space. We don't like loss of productivity to early seral stages--weeds. We want to focus all the ecosystem's productive power into one or a few valuable species. It is probably a good thing that nature hasn't allowed us to achieve our desires in the National Forests.

I would like to discuss some management practices at both the stand and the landscape levels in an attempt to look for alternatives to simplification. I will focus on the west side of the Cascades and the coast range of Oregon because those are areas with which I am familiar. I will also focus on forests because I am likewise most familiar with forest ecosystems. The principles are generally useful and should be adapted to other areas and ecosystems as appropriate.

I would like to discuss the stand level first. We are all fairly comfortable with the stand level. We have lots of experience manipulating stand features--tree species, tree sizes, tree ages, shrub composition, planting of grasses and so forth. Let's look at some of the major stand structural features that occur in forested landscapes of the Pacific Coast area. Important structural components are fairly obvious and include: large old-growth trees, large standing dead trees, large down trees on land and large woody debris in streams. We stumbled over the dead wood structures for years as we walked through the woods. We removed them where they were impediments to operations. We removed them where they weren't, for the sake of tidy appearances or from misunderstanding of their role. Large wood in streams was removed as a matter of course 20 years ago under the mistaken impression that it impeded fish passage. We now understand that those same structures perform a vast array of functional and compositional roles in the ecosystem including nutrient cycling, providing for the stability of both soils and water, and providing habitat for animals and plants.

Large trees are obvious structures. They provide a great deal of animal habitat and influence the environment for other plants. They capture most of the energy on which the ecosystem is fueled. The canopies of large, old conifers are deep and distinctive. Small ecosystems of epiphytic plants and animals are often perched on large branches. Beneath the large trees, shade tolerant trees and shrubs provide species diversity, perform nutrient cycling, convert filtered sunlight into ecosystem fuel, and further alter the environment of the forest floor by providing shade and temperature regulation.

Large snags have been unappreciated for decades. We use to cut them all down as fire and safety hazards and for firewood. We now know that large numbers of cavity nesting birds and related species depend on snags. As snags fall to the forest floor, they also play a part in nutrient cycling.

Perhaps the biggest change has been in our understanding of the role of large woody debris on the forest floor and in streams. Major portions of the nutrient cycling system occur in and around large woody debris. We used to pile and burn every large chunk of wood that would hold together well enough to get it the landing. Now we have standards in the Forest Plan requiring minimum levels of large wood to be left following timber harvest.

Let's look at the natural development of these structures. Natural wildfires generated enormous amounts of structure in the form of standing and down dead wood. During the ensuing decades and centuries, most of this initial burst of structure decayed as the new stand matured. A low point in structural diversity occurred when a large portion of the old dead wood had decayed and the new stand was not yet producing replacements. Across this continuum of structural development, there was not obvious time when the mature forest changed into old-growth. Nature doesn't work that way. Very few things in nature are black and white, yes and no, on and off. Old-growth structures begin to accumulate slowly and over time. Natural young stands often had structural complexity nearly equal to that of old-growth, brought forward from the previous stand as a biological legacy.

As a consequence, definitions of old-growth which require minimum amounts of snags, logs and other structures are overly simple. Many stands lie in the gray area between old-growth, in the classic sense, and mature

condition. This may lead to misunderstandings when stands are tagged "old-growth" or "not old-growth" during discussions with other people, both internal and external to the Forest Service. Sticking to a hard-and-fast yes/no definition of old-growth requires expensive and extensive field sampling and statistical analysis.

How can we begin to retain some of these structural features in managed stands? Common practice in the Western Cascades and coast range was clearcut, pile and burn the unmerchantable material, burn logging slash on the entire unit and plant Douglas-fir. We are now seriously questioning those practices. We have found that we can leave large green trees, snags and down wood most places. Our clearcuts are becoming less obviously "clearcuts," often resembling seed tree or shelterwood cuts. The benefits, in terms of the wildlife habitat and stand structure, seem to outweigh the problems associated with logging systems and prescribed fire.

I often heard the argument that leaving green trees in a unit results in blow down, a failure of some sort. Any time large trees remain after logging, blow down may occur. From my perspective, once you decide to commit the trees to the site, there is little reason to salvage them if they blow down unless they present an unacceptable hazard to a feature you would like to protect. While the blown-down trees are now horizontal instead of vertical, they still play important roles in the ecosystem.

We have also begun to experiment with leaving snags. The Forest Plan calls for leaving between two and four large, green snags per acre. Snags may present safety and fire hazards. However, we have found that some difficult safety issues can be resolved by allowing the purchasers or the loggers to select which snags to leave. We provide the purchaser with specification as to the number, size and distribution of snags following harvest. The loggers leave the snags that interfere the least with logging systems and pose the fewest problems for safety. Costs for fire suppression may rise if snags pose additional fire hazards. Both these considerations may increase the costs of timber harvest. An alternative to leaving snags is leaving more large green trees to become snags, also a potentially costly option. But we, as stewards of the land, must decide if the benefits outweigh the costs. Is it really good stewardship to harvest timber if we cannot retain or provide large snags or pieces of down wood that our science tells us may be critical to the long-term sustainability of the forest? I suggest that it is not.

We are also having some success in leaving behind large wood. The Forest Plan and timber sale contracts now specify levels of large woody debris on a per acre basis. The levels specified in the Plan are minima and should be treated that way. We often specify a minimum which then becomes the target.

Our view of a desirable future stand condition has moved away from our old picture of garden-like stands, with trees of uniform size and species, fully occupied by commercial species from the first year following harvest. Our new picture includes trees of several sizes, ages and species, snags and down wood, and a reasonable complement of early seral pioneer shrubs and herds into the first decade or two.

The Landscape Level on New Perspectives Management

Natural landscapes consisted of diverse and interconnected patterns of stands resulting from natural fire history. Superimposed over that pattern is the distribution of timber harvest units. On private lands, harvest has often generated large patches, several thousands of acres in some places, of young stands. National Forest timber harvest has generally resulted in small, dispersed patch cuts. On National Forest lands, where the size of the harvest units is generally 20 to 40 acres, as the landscape becomes about half cut-over, the size of the leave areas becomes approximately the same as the size of the harvested units.

Considering the encroachment of edge effects from clearcut edges (temperature, light, wind, humidity, etc.), a landscape which is half cut over in a staggered setting patch-cut pattern may have very little interior forest habitat. In fact half of the old-growth may remain uncut

and, depending on the size of the harvest units, none of it may be functioning as interior forest habitat.

We tested the effects of different landscape patterns in the Cook-Quentin area of the Blue River Ranger District. We projected 30 years of harvest following two spatial patterns: staggered setting and minimum fragmentation. The goal under the minimum fragmentation approach was to retain large blocks of intact forest and interconnections between them while generating openings that were larger than normal. The goal under the staggered setting approach was to disperse harvest impacts in the traditional fashion, using small patch cuts. We assumed the same levels of timber harvest in both cases.

We found that the staggered setting approach produced substantially more edge and less interior habitat than did the minimum fragmentation approach. The area of interior habitat remaining after 30 years was about 10 percent more with the minimum fragmentation approach than with the staggered setting approach. For the 12,000 acre study area, that amounted to approximately 700 acres more interior habitat with the minimum fragmentation approach. Pattern does make a difference. Pattern is important.

A minimum fragmentation approach is not a cure-all for questions of landscape pattern. There are some places where visual, watershed or wildlife habitat concerns overshadow the need to retain large blocks. It is not a solution for the old-growth issue over the long run because the lands in "general forest" will be harvested under the current Forest Plan. It does allow options to retain larger blocks of interior forest habitat over the next few decades. A minimum fragmentation design also generates large patches in which stand-level structure could be managed to produce large areas of land with at least some of the structures of old-growth forests. In reality, landscapes will run the gamut from dispersed patch cutting to aggregated harvest. Cook book approaches to landscape management won't work well.

Everything has its price. The practice of leaving green trees and snags and downed wood in harvested areas certainly reduces the initial harvest volume per acre and may reduce the growth rate of young stands underneath a partial canopy. It may increase fire hazard. It may not be visually acceptable in some settings. However, simplifying the structure and patterns of landscapes also has its price; a price exacted in the potential for long-term soil degradation, the loss of late seral plant and animal habitat, increased public resistance to clearcutting and, in the long run, legislated management. I think we will see very few traditional clearcuts within the next few years. Most stands on the west-side will consist of two or three age classes. The basic framework or pattern of old-growth across the landscape will be both legislated and developed in Forest Plan and field processes.

We need a much expanded box of tools and a modified set of goals. Our goal should be to manage for long-term ecosystem productivity and for the extraction of some level of commodities. Perhaps more critical than these technical fixes will be new ways of working with concerned people in the decision making process. The decisions will become partly theirs. They own the National Forests.

The bottom line that National Forest management should focus on what the ecosystem has given us to manage. We must allow that ecosystem to continue to function. We don't really understand it. We don't know all the pieces nor how they work. We should tread lightly. We should proceed with humility. And we should think carefully about slavish imitation of nature. Very seldom would we want to create impacts on the scale of Mt. St. Helens' eruptions. Land management will be more difficult and time-consuming, but, in my opinion, more rewarding.

SHASTA COSTA: FROM A NEW PERSPECTIVE

Kurt R. Wiedenmann
Siskiyou National Forest

New Perspectives embraces a wide array of concepts, philosophies and management techniques. It is difficult at best to ascertain whether a given project hides "just-the-usual" under the New Perspectives shingle or truly explores and stretches management opportunities.

The staff at the Siskiyou National Forest have long been at the forefront of innovation in resource management and they're at it again. The Siskiyou's Shasta Costa planning effort offers one of the most exhaustive glimpses of New Perspectives and Forest Plan implementation found to date.

Shasta Costa - Home for New Ideas

The Shasta Costa Planning Area presents a unique area for the exploration of New Perspectives. It includes a myriad of characteristics and conditions that complicate management decisions yet offers an opportunity to address concerns and conditions common to other planning projects.

A 23,000-acre watershed, Shasta Costa is circumscribed by two main travel routes along its north and south boundaries while the interior 14,000 acres are unroaded. The Wild Rogue Wilderness lies immediately to the north of the planning area and the Kalmiopsis Wilderness lies approximately 6-miles to the south. Previous harvest activities from the 1960's and 1970's are concentrated in the extreme corners of the football-shaped planning area.

Most of the area is covered by a mixed Douglas-fir and tanoak forest with mixed true fir and Douglas-fir at higher elevations. There are scattered open grassy sites and several large, natural brushfields. The mosaic pattern of these vegetative types as they lay across the landscape provide the map to the area's geologic, human, and fire history.

Forest Plan - Implementation Opportunity

There were two primary objectives with the Shasta Costa Project: 1) Implement the Forest Plan direction for the period of 1991 to 1993 using an integrated resources approach; and 2) explore managing for biological diversity at the project level.

The Siskiyou's Forest Plan was released in spring 1989 and Shasta Costa is the first large project to be proposed for implementation under its direction. Although the Forest Plan programmatically addresses the management of the Siskiyou for the 10-year period between 1989 and 1998, the Shasta Costa Draft EIS examines alternatives for site-specific management for the 3-year period between 1991 and 1993. The three-year period allows for the planning of a series of integrated projects in the area rather than an isolated timber sale.

An Integrated Resource Analysis was completed, prior to beginning the NEPA process, in order to identify the pool of project opportunities. A comparison was made between the area's existing condition and its Desired Future Condition as described in the Forest Plan. The difference between these two conditions constituted the pool of opportunities for management. The Forest Plan-assigned management areas were then superimposed onto this pool of opportunities to insure compliance with the Plan.

While the Sisikiyou Forest Plan stipulates the maintenance of biological diversity, specific "how-to's" are left to be determined during individual project planning. This opportunity was coupled with advances in our technical knowledge as well as a changing social climate that demands greater public participation in natural resource planning. The resulting

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three-faceted gem came to be known, for the Shasta Costa Team, as New Perspectives: New Thinking, New Technologies, and New Alliances.

New Thinking

New Thinking, for the Shasta Costa ID Team, means emphasizing the maintenance of functioning ecosystems, leaving resources biologically resilient to change, and looking at the resource from the stand, watershed and landscape perspectives.

Historically timber sales have been viewed as islands on the landscape. While their effects were estimated, their role from the wider view was seldom considered. Beginning at the landscape level, Shasta Costa ID Team members views the planning area's role and significance as it interacts with its surroundings.

Despite the perspective - be it landscape, watershed, or timber stand--instead of focusing on what is to be taken from the Forest, the ID Team focuses on what is to be left. The Team designs their projects to leave behind complex ecosystems which contain biological legacies and connections between the Forest's past and its future.

New Technologies

New Technologies involves the development of a tool kit of both old and new silvicultural prescriptions. These should be based on appropriate technical developments and scientific findings and designed to meet integrated resource objectives. For the Shasta Costa ID Team, this involves maintaining an on-going partnership with agency and university researchers.

Getting a handle on biological diversity--knowing what to maintain as well as measuring one's success at maintaining it--is a challenging endeavor. Current research is helping to shed light on these concepts and the Team's partnerships have helped them to identify key components of biologically diverse and resilient ecosystems. These partnerships also help to develop measures of this diversity.

The Team has the opportunity to utilize a Geographic Information System (GIS) for analysis and mapping. This speedy tool enables the Team to model and analyze changes and display those changes in map form. GIS is critical to the success of the project. It is an important tool for modeling and analyzing the myriad of components of biological diversity. Continuing refinement of other models for habitat capability and sediment delivery also assist the Team with the estimation of the effects of implementation.

New Alliances

Increasing political intervention often pulls resource management out of the field and into the courtroom. These courtroom-based decisions are an outgrowth of public dissatisfaction with previous decisions by the agency. That dissatisfaction can be, in part, traced to limited participation in these decisions and actions.

The Silver Recovery Project demonstrated that more thorough participation with interested parties can be a critical link in understanding the balance between people's needs and the ecosystem's needs. The Shasta Costa ID Team have gone to great length to maintain constant and active communication with affected and interested parties. These include people directly affected by management decisions, political representatives, Forest Service and other agency employees, as well as other interested parties.

Throughout the process newsletters, TV and radio spots, phone calls, and briefings keep interested parties abreast of the ID Team's progress. It is hoped that a rapport is established and that a greater understanding is reached of not only Shasta Costa, but the resource planning process in general. It is the establishment of this long-term relationship that will help interested parties to be more comfortable with public participation and, in the future, more effective as well.

Managing for Biological Diversity

In managing for biological diversity, the ID Team began to identify the boundaries and biological values of the Landscape/Watershed/Stand level areas. I would like to focus on these levels and how the ID Team developed its analysis and thought processes.

Landscape. It was important for the ID Team to identify the significance of the Shasta Costa watershed in the overall landscape. The ID Team identified a landscape of approximately 200,000 acres to try and understand it's geographic position and biological importance within the landscape. There were two primary concepts at the landscape level that the ID Team analyzed: 1) emphasizing the maintenance of landscape level habitat connections; and 2) understanding the role of natural disturbances as the major force in the development of the Forest.

Shasta Costa sits between the Kalmiopsis and Wild Rogue Wildernesses, and maintaining habitat connections between these two major gene pools is critical. Although our planning decisions would be limited to the Shasta Costa watershed, we could maintain existing corridors from within the watershed out into the landscape, connecting the wildernesses.

Understanding the natural disturbances which occur across the landscape is key to New Thinking. The Silver Fire burned nearly 100,000 acres just six miles south of Shasta Costa and became our laboratory for learning the interactive role of natural disturbances and "New Perspectives". Post-fire monitoring reveals that the fire burned in a classic mosaic pattern; high intensity burns on ridgetops and south-facing slopes, low intensity in riparian areas and fingers of moderate intensity lacing across mid-slopes.

Watershed. The ID Team began to refine their focus, once they understood the landscape significance of Shasta Costa. Initially the ID Team went back to the Silver Fire as the laboratory in which to learn. The last large natural fire occurred in Shasta Costa in 1916. The ID Team compared the trends of fire patch size, location and intensity in the Silver and 1916 fires with present distribution of vegetation in Shasta Costa. The result is a template of a natural disturbance - a sample of how a large fire might affect the Planning Area from the watershed perspective. From this, the ID Team began to ask: "How do we manage in concert with these natural disturbances, in frequency, patterns, and intensities?"

The first major step was to utilize GIS in mapping the successional stages in the Planning Area to help the ID Team understand the natural disturbance patterns, identify significant old-growth stands and habitat connections, and start to identify initial management opportunities. This was a critical layer in the formulation of alternatives and maintenance of biological diversity. It assisted in:

- modeling changes in successional stages through time.
- identifying plant associations that are under represented in the Planning Area, warranting a lighter touch on the land.
- identifying wildlife habitat for key indicators such as the pileated woodpecker, spotted owl, and pine marten.
- identifying interior old-growth habitat and low elevation old-growth habitat.

All of these assisted in analyzing the relative abundance of birds, mammals, amphibians, and reptiles for a relative abundance index of these populations.

The ID Team then began to factor in the management areas for the Planning Area, further refining options for integrated resource management in light of the major issues. An interesting side note has been the interest by research groups and timber industry to consider a management alternative which would remove all the management area allocations and consider the entire Planning Area for management under the concept of "a lighter hand on the land". We entertained the alternative, but eliminated it from detailed study because it was outside the scope of the planning effort.

Identifying habitat connections within the Planning Area between significant old-growth stands and habitat connections to the landscape was critical. The objective of habitat connections was to connect old-growth patches to provide for movement of plant and animal species for the dispersal and exchange of genetic material. These habitat connections were identified as 1000 feet wide (to provide for 200 feet of effective interior habitat assuming two tree lengths, 400 feet, of fragmentation along the sides) using immature, mature and old-growth stands. To accomplish this, the ID Team used the existing network of management areas that had little to no programmed timber harvest. Then connected the remaining network through management areas that had programmed timber harvest. The ID Team's objective is to have these as rotating connections through time in these programmed timber harvest areas. There is a concern that these are pseudo land allocations, although the ID Team intends to model the long term applicability of this concept.

Stand. Refining their focus, the ID Team began considering management opportunities at the stand level. The ID Team viewed the 1,000 plus stands in the Planning Area as a large jig saw puzzle, where we could understand the effects that stand level management would have on the watershed and landscape biological values. In achieving the integrated resource objectives for each stand, the ID Team would review proposed management prescriptions and its effects on the stand/watershed/ landscape levels. If stands were within habitat connections, or under represented plant associations, or habitat for sensitive salamanders, we would select silvicultural systems from our tool kit to maintain the biological values.

While building our tool kit of silvicultural systems, we understood that clearcutting is still a tool, although not in the pattern and frequency that we had been using for the past 30 years. So the ID Team went back to the Silver Fire laboratory to review the successful silvicultural systems at the stand level in the salvage of fire-killed timber. Additionally, the ID Team reviewed new units and old units on the Forest as to what had been successfully implemented to meet the stand level objectives of retaining large woody material, wildlife tree retention, cool spring burning, and riparian management to retain the structural integrity. The silvicultural systems in the Shasta Costa Project tool kit were designed with the objectives of maintaining and managing for: long term site productivity; long term structural integrity (green tree and snag retention); and accelerating the redevelopment of old-growth structure in commercial thinning and regeneration harvests.

<u>Rules of Thumb</u>

After completing the alternatives for the Shasta Costa Draft EIS, the ID Team identified a group of guidelines or "rules of thumb" for managing biological diversity:

Follow Nature's Lead - Mimic the natural disturbance patterns and recovery strategies in your areas.

Think Big - Manage for landscape diversity as well as within-stand diversity.

Don't Throw Out Any of the Pieces - Maintain a diverse mix of genes, species, biological communities, and regional ecosystems.

Side With the Underdogs - Prioritize in favor of the species, communities, or processes that are endangered or otherwise warrant special attention.

Try a Different Tool - Diversify silvicultural approaches. Reduce emphasis on clearcuts.

Keep Your Options Open - Use existing roads wherever possible.

No Forest Should be an Island - Minimize fragmentation of continuous forest: 1. Cut adjacent to existing clearcuts. 2. Nibble away at the edge instead of creating a new hole.

Encourage Free Travel - Create a web of connected habitats. Leave broad travel connectors for plants and animals especially along streams and ridges.

Leave Biological Legacies - Select what you leave behind as carefully as what you take out; specifically, standing live and dead trees and fallen logs.

Leave it as Nature Would - Leave a mixture of tree sizes and species on the site. Restore naturally diverse forests after harvest.

Be an Information Hound - Use the latest studies and state-of-the-art technology to design, monitor, and evaluate new approaches.

Be a Critical Thinker - Use only the scientific findings that make sense for your region and social setting.

Monitor, Monitor, Monitor - It's the only sure way to tell if you are really conserving biological diversity.

Shasta Costa Alternatives

The Draft EIS develops and examines the effects of implementation of six alternatives, including a No Action, Alternative A. Alternative B best resembles those projects proposed under the Siskiyou Forest Plan which constitute the "Proposed Action" and are the basis for initial scoping. Alternative C, the Forest Service Preferred Alternative, most thoroughly emphasizes the New Perspective concepts identified by the Shasta Costa ID Team. Alternative C includes most of the projects identified in Alternative B but designs and schedules them to maximize emphasis on New Perspective concepts--maintaining biological legacies and landscape-view connections as well as accelerating the development of old-growth characteristics in immature and mature stands and maintaining water quality. Alternative F emphasizes the scenic sensitivity of the planning area and restores fish habitat in areas that have been previously impacted by past harvest activities. Alternative G is similar to C in its use of New Perspective techniques, but concentrates more harvest in old-growth. Alternative H accelerates timber harvest above what is identified in the Forest Plan while using traditional management techniques and emphasizing timber production and local employment.

New Perspectives includes a wide variety of concepts, technologies and alliances. Each of the above alternatives includes a selection of the New Perspectives "tool kit"; Alternative C uses the widest variety of New Perspective tools and Alternative H the most limited.

As an example, the Preferred Alternative de-emphasizes clearcutting while emphasizing the retention of biological legacies at the stand level by retaining large groups of green trees, replicating the natural burn patterns found in the Silver Fire.

Proposed units have been located to emulate the location on which such a disturbance might occur. Silvicultural systems are proposed which replicate the stand-level effects of these disturbances and meet integrated resource objectives.

Lessons Learned Mid-Stream

New Perspectives is a refreshing way to "read" both the social and natural resource settings, taking nature's lead and combining the needs of both people and the environment. The Shasta Costa ID Team feels that this new approach is a healthy change in Forest Service management. But it comes, as everything else, at a cost--increased demands for both time and money. Field data collection is more intensive as we look at a wide view on the landscape. The implementation of silvicultural prescriptions is more time-consuming as they are carefully tailored to the site. Building partnerships with people of divergent interests and views takes not only time and money, but patience, courage and honesty.

Many detractors of New Perspectives question what was "wrong" with the old and what is so "new." And in truth, many of the technologies are not new--but the way the various techniques are combined, designed, and timed <u>is</u> new. These combinations, when used with the latest in technology and in conjunction with active alliances, are New Perspectives.

Social response to Shasta Costa and its implementation of New Perspectives is mixed. Local conservation groups express cautious optimism. These groups recognize that this

approach represents a changing philosophical perspective--one that is consistent with many of their concerns. At the same time, they are cautious about endorsing New Perspectives in a way that would allow it to be a vehicle and a guise for violating many of their basic conservation tenets. Understanding that the National Forests cannot, in practicality, be reserved from all harvest activity, conservation groups at both the local and regional levels do recognize that New Perspectives may be a method of compromise between protection and production.

Local industry, on the other hand, is more sensitive to the potential reduction in harvest volume. While New Perspectives may help to alleviate the courtroom dilemmas at the national level, a reduction at the local level as a result of New Perspectives translates into jobs and people all too quickly. Regional and national industrial groups, however, appear more open to the presentation of New Perspectives. From their position, keeping harvest decisions in the hands of resource managers may avoid carte blanche court-ordered withdrawals. An incremental reduction may be, in the long run, more desirable than vast set-asides.

* * * *	**Plant Communities, Species and Genetics**	* * * *

Session Chair: Wendel Hann

Plant Communities
Miles Hemstrom,
Willamette N.F., Ecologist

Sensitive Plants and Natural Areas
Angela Evenden, R.O.
Regional Botanist

Genetics and Biodiversity
George Howe, R.O.
Geneticist

Workshop 2A -- *How do we mange for special or limited habitats, such as riparian and old growth habitats?*

Workshop 2B -- *How do we manage for important structural components within harvested habitats?*

PLANT COMMUNITIES

Miles Hemstrom
Willamette National Forest
Ecologist

One of the things that came out of yesterday afternoon's work, to me at least, was a sense of frustration. Managing for biological diversity is like a column of smoke. From a distance it looks solid, but as you get closer and try to grab hold of it, it slips through your fingers. Fortunately, I think that there are some practical beginnings that I would like to discuss this morning.

What is biological diversity in a pragmatic, operational sense at the level of the landscape, watershed, or project? A classic scientific approach would involve an enumeration of species: take plots and tally up the number of species. If you had the time and money you would study abundance and demography, age classes, reproductive status, and genetics. These data would allow you to calculate species richness, population levels, distribution, and possibility of extinction.

But how can you do that on landscapes that range from hundreds of thousands to millions of acres, containing hundreds or thousands of species, many of which live beneath the soil surface? Many species that we would like to know about, and that are very important to ecosystems, are part of the "hidden diversity" of the land--fungi, invertebrates and microorganisms. As we found with in the case of the spotted owl, demographic and genetic studies can be hideously difficult and expensive, even with an obliging creature which will come when called. Even if we could sample and census species, how do we tell if the changes we might track over time are due to factors related to our land management or are due to other influences such as climate change, competition, and disease?

We can build an assessment of biological diversity based on three elements: endangered/threatened/sensitive species, management indicator species, and habitat diversity.

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Legal mandates require us to manage endangered, threatened, and sensitive species in specific ways. In some cases, we must perform intensive and expensive analyses of species distribution, demography, and genetics. As we know, such studies are tremendously costly and time-consuming. Our goal, in any case, should be to keep species from becoming endangered.

Forest Plans also generally call for analysis of management indicator species. These species are supposed to be surrogates for a host of others with similar habitat requirements. In many cases, however, they may be more important for their social and economic value than as broad barometers of ecosystem health. We should review lists of indicator species carefully and choose those which better represent groups or guilds of other species. Tracking habitat and populations of management indicator species, while not as intensive as for threatened and endangered species, can be expensive and time consuming. We cannot be confident that the chosen species are good barometers in any case.

Most organisms depend upon plant communities for habitat. Habitat conditions that organisms experience depend upon vegetation composition and structure. Tracking and analyzing habitat diversity can be the third leg of a three-pronged approach to managing biological diversity on the National Forests.

Habitat diversity can be viewed, perhaps in an overly simple way, as the distribution of plant associations (habitat types) by seral or stand structural stage across the landscape. Plant associations, or habitat types, provide an indication of site environment, the potential natural vegetation, and the directions and rates of change in seral vegetation. Existing stand structure, when combined with plant

association, provides a picture of plant communities, wildlife habitat, and the current successional state of the vegetation. Habitat relationship models for groups or guilds of animal species can be based upon plant association and seral or structural stage.

However, seral stage, as described by a development path from early seral (open shrubs and seedlings), through mid-seral (pole through mature tree stands), to late seral (old-growth) and climax (a special case of old-growth), may be a too simple description of existing habitat. Within each seral stage, a set of structural conditions relating to the number of remnant large trees, down wood, snags and so forth, may be necessary to adequately describe habitat conditions.

We should be able to make reasonable estimates about changes in habitat diversity over time by using plant association and seral stages, since succession is a function of both. In addition, we can estimate the vegetative reaction of plant associations to management activities. These estimates can be used to help us predict the cumulative effects of management actions on landscape level diversity.

If we monitor plant associations by seral stage in wilderness areas or other reserves, we will have a baseline against which to judge change. Global climate may change for reasons not directly related to Forest Service land management. We may not understand why changes occur in reserved areas. But at least we can expect that similar changes might be taking place in managed lands and might not be directly due to management activities.

In sum, I think the way to go about tackling this column of smoke called biological diversity management is to use a combination of special species surveys (endangered, threatened, sensitive, and management indicator species) with landscape level analysis of plant associations by seral stages. We can begin right away, using the knowledge and data we have, in project planning areas.

I wish I had a good example of treating the full array of plant associations and seral stages across a large landscape, but I don't. I don't know of any currently in existence, though some are in the works. The Shasta Costa project discussed by Kurt Wiedenmann earlier is a start. I do have an example of an analysis of one particular seral stage, old-growth, and its distribution across a reasonably large landscape over a period of 60 or 70 years.

This project started out more than a year ago, even before Congress passed Section 318, requiring that the USFS Pacific Northwest Region, meet certain levels of timber harvest and, at the same time, avoid harvest in "ecologically significant" stands of old-growth. The question, "What is an ecologically significant stand of old-growth?" immediately comes to mind. Unfortunately, there is no easy answer. All stands are significant to some degree. We had to develop a process that considered old-growth stands across a landscape and ranked them in accordance with some ecological criteria.

My example comes from the Fall Creek area on the Lowell Ranger District. The methodology developed for this 20,000 acre watershed was simplified and applied to all the timber sale planning areas across the Forest to meet the requirements of Section 318. The steps in the Forest-wide process were:

1. Choose the stands that meet a basic definition of old-growth from a Forest-wide map of stand conditions. Aggregate these stands into blocks of old-growth on maps.

2. Evaluate each block of old-growth according to a list of criteria that include stand and landscape attributes, including the size and shape of the block, the presence of unique structural features (particularly large or old trees), the presence of unusual plant communities (particularly wetlands and other non-forest communities), and the role of the block as a tie or connector between other old-growth blocks beyond which the forest-wide process stopped.

3. Compare the rating of blocks in which harvest was proposed to prioritize harvest in the blocks with the lowest rank.

The effort on the Lowell project went an additional step:

Develop proposed harvest patterns into the future to examine the long-term effects of harvest on the existence and interconnection of the most ecologically significant blocks of old-growth. Six different harvest alternatives were projected to the end of the first rotation (60 to 70 years).

Stand conditions varied widely within the Fall Creek study area, including large areas of old forest, many managed stands less than 40 years old, mature stands 100 to 150 years of age, and young stands resulting from recent wildfire. Most of the older stands met our structural definition of old-growth. These were aggregated into blocks for analysis in our geographic information system (GIS). Aggregated blocks of mature and old forest revealed complexity and interconnection at the landscape scale, punctuated by substantial areas of dispersed patch-cut timber harvest.

Considering the diversity of the shapes and sizes of the interconnected blocks of mature and old forest, the first question was: How can we break this extremely variable set of interconnected stands into areas that can be evaluated as old-growth stands and managed as a resource in themselves?

The aggregated stands consisted of nodes or focal points of large, consolidated stands, areas that were mostly edge which connected large stands (connectors), areas that were mostly edge which did not connect large stands (stringers), and small, isolated fragments. We used edge effects to help separate large contiguous blocks of interior forest habitat from connecting corridors, stringers, and isolated small stands. We used a rule of thumb that edge effects extend about 400 feet (two tree heights) into stands, based on a small amount of existing research. Areas largely within 400 feet of an edge were designated corridors, stringers, or isolated fragments. Each block, including stringers, corridors, and isolated fragments, was then ranked according to the following criteria:

To what degree does the block meet our basic structural definition of old-growth? This definition, known as PNW-447, depends on the size and number of live trees, the number of canopy layers, the number and size of snags, and the amount of down wood on the forest floor. We recognized that many stands meet part of the requirements of the definition, but not all, and attempted a sliding scale evaluation.

What is the area of the interior habitat in the block after subtracting edge effects?

What is the topographic situation for the block? Is it an entire small watershed and, therefore, a self-contained ecosystem? Is it on a hillside completely surrounded by openings?

Are there unique features such as small wetlands, unusual plant communities, unusually large or old trees?

How much evidence is there of human intrusion (roads and timber salvage, for example)?

Blocks with large areas of interior habitat, that contained all the structures in our old-growth definition, had unique features, and that were entire small watersheds were ranked highest. Other blocks were ranked lower on a sliding scale. No stand which met any portion of the criteria was ranked zero. All were "ecologically significant" to some degree.

The fourth step in the process was to look at long-term impacts of harvest on the pattern of the most significant blocks and their interconnection. How can the landscape pattern of existing old-growth stands be used to develop a harvest schedule that maintains, for as long as possible, the interconnections and viability of those most highly ranked blocks?

We started with a map of the most highly ranked blocks. We added areas not allocated for timber harvest in the Forest Plan. Since most of these were riparian areas, they formed a set of interconnections between many of the most highly ranked blocks. After examining the resulting pattern, we found that some of the most highly ranked stands were not well connected. We then added additional connections to build the basic set of highly ranked stands and minimum connections. We then

added a second level of less critical connections and the next level down in ranked blocks.

The resulting map shows areas where timber harvest will have the least impact on a basic network of ecologically significant old-growth across the watershed. Our scheduling analysis for the rest of the rotation indicated that the basic pattern of the highest ranked stands and connections could be maintained for about 3 decades with a minimum fragmentation harvest design. A traditional dispersed patch cutting pattern would fragment most of the highly ranked blocks in the first decade.

Two important results of our Fall Creek exercise are: 1) Biological diversity impacts cannot be properly analyzed without a landscape view. In Pacific Northwest ecosystems, 10,000 acres are probably a minimum area to consider. 2) Biological diversity impacts must be addressed over a long period of time. Changes caused by management may not be apparent until harvest is projected a decade or more. Management impacts to biological diversity at the landscape scale are cumulative effects.

The impacts of landscape pattern on wildlife habitat and dispersal vary greatly depending on stand structure. Larger harvested areas under a minimum fragmentation design would start to acquire some of the structure of old stands in one hundred years, depending on site quality, if substantial quantities of green trees, snags, and logs remain after harvest. The porosity of the landscape to the dispersal of interior forest organisms is much different than if larger areas are harvested without structural retention. High levels of retained structure may reduce or eliminate the need for corridors that connect old-growth stands.

By taking the process another step or two, we could address the question of the distribution and amount of the "invisible" diversity in the landscape. Most of the inconspicuous, secretive organisms that live in forests depend on vegetation for habitat. Mapping plant associations (habitat types) in combination with seral stages or stand conditions allows us to examine the distribution and abundance of habitat diversity across the landscape. Combined with a reconstruction of fire history, a map of plant associations could give us a general picture of the proportion of each plant association in each seral stage over the past few hundred years. We could then judge the deviation of managed landscapes from the natural distribution of habitat diversity. The scheduling of harvest into the next several decades could be evaluated for each proposed alternative in the management plan for the landscape.

I hope that I have provided food for thought. There are some real and concrete ways to proceed with evaluating biological diversity in land management. The process need not be terribly expensive. A map of plant associations or habitat types is probably the most costly ingredient. A map of seral stages can be developed, in rough fashion, from existing vegetation or timber type maps. A few tools, specifically a GIS, would be helpful. Field plots are probably necessary to get an idea of the species diversity in each combination of habitat type and seral stage. An idea of the typical distribution of seral stages for the past few hundred years can provide a benchmark for comparing managed landscapes to the seral condition of natural landscapes. Once those basic tools are in hand, an analysis of the distribution of habitat diversity at the landscape level is possible.

SENSITIVE PLANTS AND NATURAL AREAS

Angela G. Evenden
Regional Botanist

Introduction

An important part of the Northern Region's efforts to manage for and to maintain biological diversity are botanical resource and natural areas management. Within the last few years the Region has been developing a botany program dedicated to improving our understanding of botanical resources and managing for the maintenance of viable populations of all native plant species on our National Forests. In addition, the Region is engaged in natural areas management. The goal of the natural areas program is to identify and protect a representative array of common and unique plant communities distributed across the landscapes we manage.

The Northern Region is endowed with a unique diversity of landscapes, from moist western redcedar and western hemlock forests in northern Idaho to remnant tall grass prairie ecosystems in southeastern North Dakota. Floristic diversity of the Northern Region is high, owing to large environmental gradients, especially east to west, and altitudinally. As land managers, we have typically focused on understanding and managing a few of the more common plant species and communities. Recently, however, we have increased emphasis on the management of sensitive plants and animals. The Region initiated efforts in sensitive plant management in 1988 when the first Regional Sensitive Plant List was issued. Sensitive species are those taxa for which we have determined there is a concern for population viability as evidenced by a current or predicted downward trend. There are 122 plant taxa on the sensitive plant list for the Region. A major objective of the botany program is to develop and implement management practices and conservation strategies to ensure that species do not become threatened or endangered because of Forest Service actions and to prevent the need for listing.

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Sensitive Plants

Within the Northern Region we are concerned with four categories of sensitive plants: endemics, peripherals, disjuncts and species which are sparsely distributed rangewide.

Endemics are those species which are known from a particular locality or region. We often make reference to narrow endemics or regional endemics, with the former being very restricted in their occurrence, often to a specific geologic type or a mountain range. Occurrence of endemism in the vascular plant flora of the Northern Rockies is fairly limited; for example, only 11 species of vascular plants are known to be endemic to the State of Montana. This is from a total flora of 2400 species in the state. There are many reasons for the relatively low levels of endemism in the Northern Rockies, not the least of which is the extensive glaciation and the relatively short period since the last glacial activity. An example of a Montana endemic plant species is the few-seeded bladderpod (Lesquerella humilis). This is an alpine species known from only three mountain peaks in the Bitterroot Mountains. In addition, all three sites occur within the boundaries of one Ranger District on the Bitterroot National Forest.

Peripherals account for the vast majority of species on our sensitive plant list. These are occurrences of species living at the edge of their geographic range. These are important to consider since populations on the edge of their range may often represent the genetic extremes. Because of this they might have peculiar environmental adaptations which may prove important if the predictions of changing climatic patterns are true. Many species are found at the edge of their range in the Northern Rockies. Several boreal species

such as the linear leaved sundew (Drosera linearis) and sparrow's egg lady's-slipper (Cypripedium passerinum) extend south in and around sphagnum bogs of the northern Continental Divide Region in Montana. Similarly many species are found at the edge of their range from the west, east and south. Eastern North Dakota represents the western extent of many eastern deciduous forest species such as the showy lady's-slipper (Cypripedium reginae). The western part of the state is the eastern extreme for many species more common to the west.

Disjuncts are another category of sensitive plants on our list. Disjunct populations are geographically separated (and, therefore, no longer interbreeding) from the main range of the species. Northern Idaho is home to a number of coastal disjunct plant species. Relict coastal forests have survived since the Pleistocene in several low-lying and protected river valleys on the Clearwater, Nez Perce, and Idaho Panhandle National Forests. A particularly notable example of a coastal disjunct in this area is the Pacific Dogwood, Cornus nuttallii. The only population of Pacific Dogwood known from east of the Cascade Mountains occurs in the vicinity of the confluence of the Lochsa and Selway Rivers. This particular disjunct has been the subject of much concern over the past few years. In 1987, scientists observed extensive mortality in the dogwood population in the Clearwater Basin. Since that time genetic, mortality, and pathogen studies have been conducted in this population. More work is needed to determine to what extent this is a natural phenomenon and to determine what conservation strategies may be necessary.

Endemics are also an important part of these relict coastal forests. Several species are endemic to these particular forests, including the annual bank monkeyflower (Mimulus clivicola). This particular species became well-known to the Region when it was found in an area proposed for a road development through the proposed Aquarius Research Natural Area on the Clearwater National Forest.

Sparsley Distributed Rangewide. The four category of sensitive plants are species which are uncommon throughout their entire range. These species may often be restricted to specific and uncommon environmental conditions. An example of this group is the giant helleborine (Epipactis gigantea) which is principally associated with warm springs in the Northern Rockies. This species is also tracked as a sensitive species in several other states in the west where it is similarly restricted in occurrence.

Some species were once more widely distributed and have become sensitive due to human or other influences. Two examples of this situation in our Region are the western prairie fringed orchid (Platanthera praeclara) and an aquatic species, the water howellia (Howellia aquatilis). These two species are the Region's highest priority TES plants. The western prairie fringed orchid, which was recently listed as threatened by the United States Fish and Wildlife Service (USFWS), has principally been lost throughout its range due to conversion of its habitat to farmland. The largest remaining population of this species occurs in low-lying sedge dominated swale habitat on the Sheyenne National Grasslands. A recovery team has been appointed by the USFWS and a recovery plan is being developed.

The water howellia is another example of a species which was once known to be more widespread. Most of the known remaining populations of this species occur in glacial pothole ponds on the floor of the Swan Valley on the Flathead National Forest. A couple of small populations are known from Washington and Idaho, but the species is believed to be extripated from Oregon and California. It is currently classified as Category 1 by the USFWS.

The challenges in managing for sensitive plants in the Region are great. Management for sensitive plants, as well as other species, requires an understanding of species distribution and ecology. Since plants exhibit a great range of life histories and demographic patterns, it would be impossible to develop a single approach for management of all sensitive plants. Each species is unique in its combination of life history traits such as mode of reproduction, mating system, pollination biology, and seed dispersal.

During the past three field seasons the Region has been involved in sensitive plant inventory work. Much of this work has been accomplished through challenge cost-share projects with the Natural Heritage Programs as well as by temporary botanists. As a result of this work our knowledge of sensitive plant distribution and ecology is rapidly growing. For example, prior to the 1986 field season only four sites of the divide bladderpod, Lesquerella klausii, were known in Montana. Today we now know of 30 populations of this state endemic species.

Information of sensitive plant identification and management has been made available to Forest employees and others during the past 2 years. Sensitive Plant Field Guides have been produced for each Forest in the Region, and sensitive plant training sessions have been conducted on several Forests.

Monitoring is another important component of sensitive plant management. Studies are required to better understand long-term population trends and responses of plant populations to management treatments. Long-term demographic monitoring has been initiated for some of the higher priority sensitive plants.

Information generated from inventory and monitoring work is critical to our ability to make informed decisions on the effects of our land management activities on botanical resources. We need to have a context within which we make decisions. This winter, sensitive plant species management guides will be developed for the bank monkeyflower and water howellia. These management guides will help provide a context within which we can make more informed decisions on sensitive plant management. In addition, the Regional Office will be drafting a Regional handbook supplement on the Botany Program, and drafting guidelines for conducting biological evaluations and effects analysis for sensitive plants.

Natural Areas

Another important program addressing the maintenance of biological diversity in the Region is the Natural Areas Program. This program serves to link together in a comprehensive network, area which are specially designated to maintain natural ecosystem features. Included in the natural areas network are research natural areas (RNAs), wildernesses, semi-primitive management areas, wild and scenic rivers, and several classes of special interest areas (SIAs) such as botanical areas, zoological areas, and primitive areas.

Natural areas have a very important role to play in efforts to manage for and maintain the biological diversity found within the Northern Region. A strong natural areas network will contain representatives of as many of our typical and unique ecosystems as possible. The design of the entire network, as well as that of individual natural areas, will be very critical in helping to meet goals of maintaining diversity. At the landscape level, consideration to natural area size, shape, juxtaposition and interconnectedness will influence our effectiveness.

At an individual level, each natural area will serve as an important reservoir of genetic, species, and plant and animal community diversity. For example, the Lochsa RNA on the Clearwater National Forest, contains a portion of the only population of Pacific Dogwood east of the Cascade Mountains. Preliminary genetic studies indicate that this population is genetically distinct from its west coast counterparts.

Another area on the Clearwater National Forest, the Aquarius proposed Research Natural Area (pRNA), contains one of the best remaining examples of the unique relict coastal forests of northern Idaho. Populations of 16 sensitive plant species and several rare invertebrates occur within the boundaries of this natural area.

Other natural areas are chosen to represent more typical or common situations, such as old-growth larch on the Plant Creek RNA within the Lolo NF.

In the Northern Region we are fortunate to have large expanses of natural landscapes within our wilderness system. There is no doubt that these areas play a pivotal role in our ability to maintain biological diversity of the Region.

Values of natural areas are many. They provide representative areas which we can study to better understand the composition, structure and function of our ecosystems. They are reference areas which we can use to compare and measure the effects of our management activities. In addition, they serve as reservoirs of biological diversity, both for species we now know and those which remain to be discovered. They are the pieces of the landscape that we put into a savings bank for the future. By maintaining representative pieces of our ecosystems in an unaltered condition we are maintaining options for the future.

An important component of the natural areas network are research natural areas. These are areas established to protect a wide spectrum of pristine representative areas that typify important forest, shrubland, grassland, alpine, aquatic, geological, and similar natural situations. These areas are used for research, study, observation, monitoring, and educational activities which maintain unmodified conditions.

RNA targets were developed with the intention of locating and protecting representatives of all the vegetative and aquatic habitat types and community types described for the Region. A total of 170 RNA targets were identified in the 1983 Regional Guide. Subsequently, 120 areas have been proposed for RNA designation in forest plans. Of these, 36 are now officially established. Ten of these areas occur in Montana, one in North Dakota, and the remaining 25 in northern Idaho. We are making good progress on drafting establishment records for the 84 remaining areas identified in forest plans. Each Forest has a Natural Areas Coordinator to help facilitate establishment and management efforts. We also need to move ahead in identifying and protecting new areas to assure we have a quality and representative network.

As mentioned earlier, all types of natural areas need to be included in this network, including SIAs, Wildernesses, and other roadless areas. The small size of many of our natural areas poses a problem in conserving the biological diversity of each area. It does make sense to look at larger areas where possible. In addition, perhaps we can be looking at a collective network of all set-aside designations and how they are linked within the landscape, and in this way achieve a greater whole. Even with the problems of size, natural areas are, and will remain an important part of our efforts to conserve biological diversity. Perhaps, as we design our landscapes of the future, natural areas will figure prominently into the design and configuration of the reserve matrix.

In Montana we coordinate our efforts with a statewide interagency Natural Area Committee. A similar group in Idaho will be formed in the near future. Natural areas work is also being coordinated with a variety of cooperators including The Nature Conservancy, Natural Heritage Programs and universities. Dr. Joan Bird, Public Lands Coordinator for the Montana Field Office of The Nature Conservancy (TNC), has been working with Montana Forests on the identification and protection of new natural areas, and especially new botanical areas to protect sensitive plant habitat. Dr. Jim Habeck, of the University of Montana, has been instrumental in collecting baseline ecological information and preparing establishment records for many RNAs in Montana.

We are working in an exciting time of change within our agency. We face many challenges ahead as we continue to learn more about the intricate relationships and diversity of our natural ecosystems. Wise management of our botanical and other natural resources will most certainly be based on management strategies which allow for the continued maintenance of the biological diversity associated with the natural landscapes of the Northern Region.

GENETICS AND BIODIVERSITY

George E. Howe
Regional Geneticist

Introduction

I want to address two themes today. The first is guarding against the wrong risk, which may waste time better spent on avoiding the higher priority risks, and make us vulnerable to legitimate criticism. I focus on genetic considerations in assessing minimum viable populations. The second theme is the genetic effects of major forest management activities. Geographically, I restrict my attention to Northern Rocky Mountain forests.

Early in 1981, Danielle Jerry, Wildlife Biologist for the Idaho Panhandle National Forest (IPNF), drafted recommendations for preserving old-growth on the IPNF for the benefit of the Selkirk caribou herd. She had clearly spent great time and energy applying the "rule of 50/500" to the particular problem of the Selkirk herd. The "rule of 50/500" was proposed, so far as I can determine, by a conservation biologist named Ian Franklin in a chapter in Soule's and Wilcox's *Conservation Biology*. The chapter was entitled "Evolutionary Change in Small Populations." The rule says that for the genetic health of a wild species (or population) the effective population size should not be allowed to decline to less than 50 for the short run, and should be built up to and maintained at no less than 500 for the long run. Without going into the mathematics of his arguments, Franklin built his case essentially on two cornerstones: 1) depletion of genetic variation (variance), and 2) inbreeding depression. Franklin's chapter had some errors, some of them serious, but the rule of 50/500 seems to have been generally adopted. If so, I suspect it was because Franklin himself recognized some caveats. Danielle Jerry would have saved herself time if she had paid attention to the caveats.

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Depletion of Genetic Variation

Small population size. So let's consider depletion of genetic variation with small population size. Here's the quiz question: In a stand of old-growth Douglas-fir in the Bob Marshall, if we select, at random, one individual from the population, about what proportion of the genetic variation in that population will be represented by that one individual? Here are your choices for answers: 1%, 25%, 50%, 75%, 99%. Hyun Kang, just 2 weeks ago reminded Forest Service geneticists of these principles at a national meeting in Wenatchee. Hyun Kang heads a one-person project in the North Central Station entitled Long-term Strategies and Techniques in Forests Genetics. He is a quantitative geneticist.

Hyun Kang was using the process proposed by Ian Franklin. Indeed Dr. Kang stepped us through this quiz question by starting with the formula on page 139 of Franklin's chapter (the formula for calculating effective population size for populations fluctuating in size). The answer to the quiz question is 99 percent. And the principle applies in general to any population if we couch the quiz question in these terms. If our new population is a characteristic sample of the larger, former population, the new population will contain most of the genetic variation of the old. The point here, of course, is that small population size itself does not necessarily deplete genetic variation. But that's not usually the issue. The issue usually is, what happens in the new population? What was the genetic variation status of the old population?

Inbreeding

If this new population of one Douglas-fir tree is now self-fed (Douglas-fir is monoecious), we have imposed the severest form of inbreeding, and we have just cause for concern for the offspring of this cross. In Douglas-fir and most other higher plants and animals close inbreeding leads to inbreeding depression.

Franklin lists inbreeding effects: "Inbreeding has deleterious effects on survival and reproduction, and affects such characters as growth rate and adult size" (p. 140). Alan Orr-Ewing showed these characteristics in some classic experiments in selfing Douglas-fir in British Columbia in the late 50's. I once heard Micheal Soule say that inbreeding is ALWAYS deleterious. This may be a bit of an overstatement (it will come as a real surprise to those species of slugs who are obligate selfers!), but inbreeding without the benefit of offsetting processes rapidly decreases heterozygosity and can lead to inbreeding depression, especially in species with an evolutionary history of outcrossing.

Franklin states that in mammals and birds (which have low inherent reproductive rates), "inbreeding depression is the most important consequence of reduced population size" (p. 140). Curiously, Franklin offers no experimental evidence of the assertion and, in fact, in the next paragraph adds a caveat which further subtracts credence: "Immigration of unrelated individuals into an inbred population reduces the level of inbreeding dramatically". Danielle Jerry missed this very important caveat. Immigration is an extremely powerful reducer of inbreeding and generator of genetic variability! Franklin cites Avery as suggesting that migration rates in the order of one individual per generation increase the overall genetic variability.

Rare episodes of close inbreeding are regarded as beneficial by many evolutionists. Perhaps the most important cause of inbreeding depression is the revelation of deleterious recessive alleles as homozygosity increases and the recessive alleles are "unmasked" and express themselves. If the episode of close inbreeding is followed by intense selection to rid the population of the deleterious recessives, then the population is far less likely to be adversely affected by inbreeding depression in the next episode of inbreeding. More important, there is evidence that the carrying of numerous deleterious recessives genes (the genetic lode) in herterzygotes itself imposes some reduction of fitness. On an evolutionary scale, episodes of severe bottlenecks in population size have certainly occurred in the conifers of the Northern Rockies, and with these bottlenecks probably some fairly close inbreeding. If we are honest with ourselves, I suspect we will concede that virtually all our higher plants and animals experienced close inbreeding from time to time prior to the influence of agricultural man.

This view of the role of close inbreeding followed by selection is not just speculation. The principle was put to practical use by Alan Templeton and Bruce Read for ridding a population of Speke's Gazelle of its inbreeding depression (Benjamin and Cummings, 1983). All captive animals in the U.S. trace their ancestry to one male and three females imported into the U.S. in 1969 and 1972. By the early 1980's the population had grown to 29 individuals in three zoos. The population had no hope of achieving the short-term minimum of 50 proposed by Franklin, let alone the long-term minimum of 500. There was also no possibility of avoiding inbreeding; indeed the population by 1979 was already highly inbred.

Templeton and Read designed a multigeneration herd management program and mating scheme built on two cornerstones: 1) use of parents who were already inbred but proven in their viability, and 2) maximizing genetic variability within the limits imposed by the narrow genetic base. These parents were the product already of several generations of adaptation to inbreeding. Each generation the managers of the herd rigorously eliminated offspring which exhibited serious inbreeding depression (and they controlled crosses to maximize genetic variability).

How well did the program work? In the words of the authors, "...much, if not all, of the inbreeding depression [was] eliminated in our selected animals" (p. 261). Templeton and Read view inbreeding depression as "...a temporary maladaptive syndrome that occurs during the transitional period from outcrossing to inbreeding" (p. 245). Assuredly this is not an endorsement for programmed inbreeding in species with a history predominantly of outcrossing, but it does show that selection can purge a population of its genetic lode. Nature surely has done so occasionally in most species.

Are the effective population sizes we are dealing with less than 15 or 20 individuals? Sometimes, but probably not for more than

one or two generations. If this assumption is correct, we probably should not be concerned about the effects of inbreeding unless we have measurements suggesting inbreeding depression. If we see such evidence, can we regard this as an opportunity to reduce the genetic lode in the population or species, and, in doing so, mimic past (and future) natural events? Perhaps, but with great caution.

Selection

In his "Evolutionary Change in Small Populations," Franklin devotes attention to depletion of genetic variance due to natural selection, and concludes (p. 143), "Strong selection reduces additive variance..." In an earlier paragraph, however, he appears to contradict this conclusion. He reviews a classic Illinois corn experiment in which there was continued response to selection for 76 generations with no measurable change in genetic variance (Figure 1). Selection began in 1896 with a starting population of 63 open pollinated ears. Franklin concludes, "These experiments demonstrate convincingly that additive genetic variance is not depleted rapidly by selection". With this I agree. The selection we are practicing in our tree improvement program will not deplete genetic variance in the populations of selectively bred trees we are planting, nor will genetic variance be depleted by unconscious selection in grizzly bears, pileated woodpeckers, Selkirk caribou, etc.

The Priority Risks, The Genetic Risks, Loss of Rare Alleles

Even though genetic variances may not change as population size reduces, rare alleles are vulnerable to loss. Some of these will be important to the future evolution of the species, and we should set standards for minimizing their loss. Danielle Jerry offered a rational suggestion: compare the rates of loss of rare alleles to the rates of mutation creating those alleles. In doing so, however, we need to guard against the temptation of setting standards inconsistent with the evolutionary history of the species. What has been the frequency and pattern of bottlenecks in the natural history of the species? What's "rare" and how do we estimate how many alleles that rare or rarer are in a species and how rapidly they are being lost?

Change in Means

Let me return a moment to the Illinois corn experiment. You remember that the experimenters found no change in genetic variance after 76 generations of selection for high and low concentrations of oil. What they did change was the means for the two traits (Figure 1), as we would expect. The mean for high oil concentration increased from about 5 percent to almost 19 percent. Low oil concentration decreased to about 0.2 percent. So the good news is that we can change means by selective breeding (or unplanned selection) without changing genetic variances.

The bad news is that we may change means in the wrong direction (Figure 2) by selection (either conscious or unconscious), and it may be easier to move means in the negative than in the positive direction. Consider Figure 1 again. Despite approximately equal selection intensity for low oil and for high oil, the change in mean for high oil was markedly faster, even in the early generations, than the change in mean for low oil. We may consider low oil and high oil to be opposite sides of the coin, but high oil is much more sensitive to selection than low oil. If high oil concentration were an undesirable characteristic to us, we might be much wiser to avoid unplanned selection for high oil than to practice positive selection for low oil concentration.

I believe the phenomenon operates in forest trees. Bill Libby calls this phenomenon "asymmetry of response to selection." There is a small but persuasive body of evidence in the forestry literature that it is easier to achieve genetic losses in native forest trees by selecting the "sick, lame and lazy" than it is to achieve genetic gains by intensive positive selection for the same trait. Libby attributes the form of the Monterey pines on the Monterey Penninsula today to several successive rotations of high grading. The ancestors of the modern population were prized by the Spanish settlers for ship masts, and the settlers kept cutting the best and leaving the worst to regenerate the next stand.

Figure 1. Mean percent of oil in ears of *Zea mays*--selected (IHO) and low (ILO).

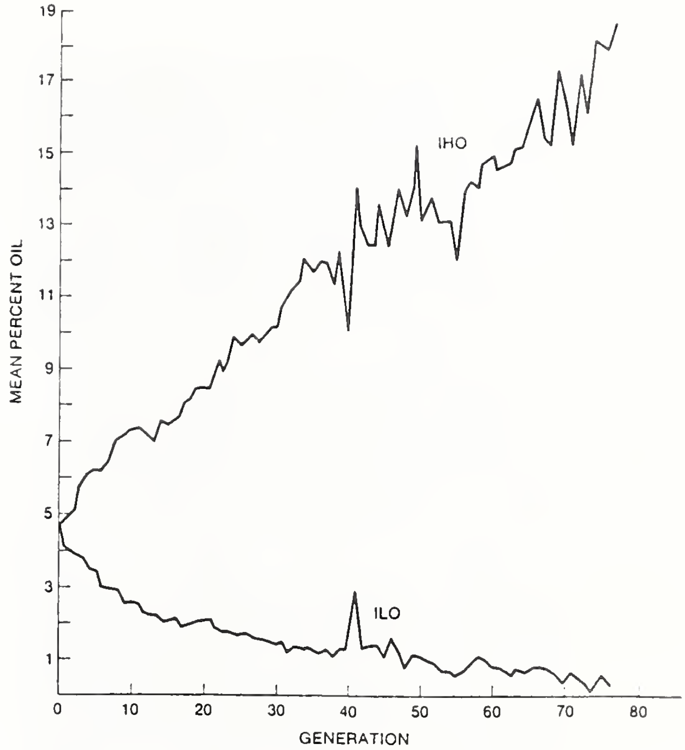
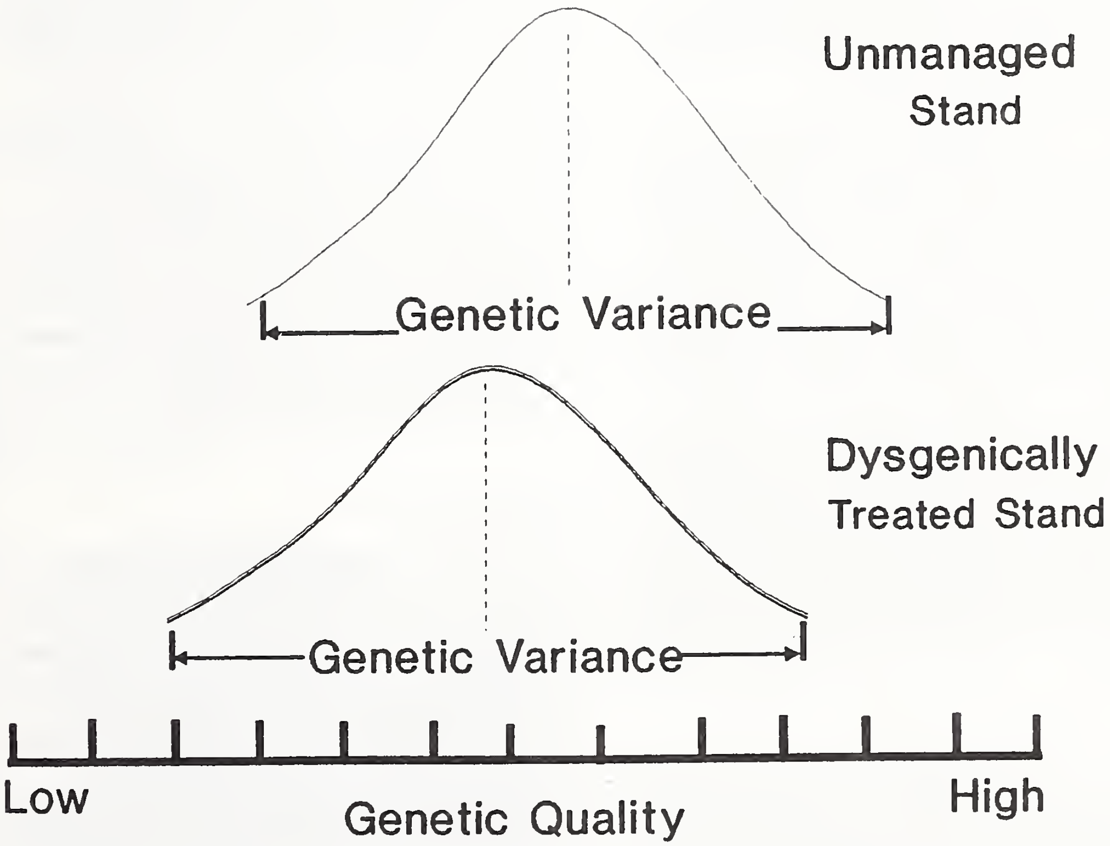


Figure 2. Changes in genetic quality.



Indeed, the settlers argued for Monterey to be their state capital because of the value of shipbuilding and the contribution to it of the local pines. Today's Monterey pines, there, are certainly picturesque, but hardly virtuous for ship masts (or poles, or lumber, etc.). Options available to our ancestors, and options we might appreciate today in this population of Monterey pine, have been lost because of dysgenic selection. Have these forests also lost value as habitats for other plants and animals as a result of their altered form attributes, competitiveness and growth patterns? I think so. They are certainly less productive by any measure of biomass.

We should be particularly cognizant of dysgenic selection of native forest trees for insect or disease susceptibility. There is unequivocal evidence that insect and disease susceptibilities in general are moderately to strongly heritable. If our naturally regenerated stands are emanating principally from the most diseased or infested trees in the stand, we are setting our forests up for declines that are inherited! All the plants and animals that depend on healthy forests will suffer. The sweeping, forked, slow-growing or budworm susceptible Douglas-fir tree may be the forest's equivalent to hip dysplasia in mammals.

We all have a stake in growing healthy forests because these forests support components of every resource we manage, no matter if it be fish, grizzly bears, eagles, clear water, red meat, scenic vistas or timber. We all should be together in urging our line officers to resist the temptations to leave the sick, lame and lazy as the parents of our future forests. Mother Nature rarely regenerates forests predominantly from the most diseased or infested trees in a stand. At worst, the seed emanates from a random mix of sick and healthy trees---as when the pest does not affect reproductive capacity. More commonly, diseased or infested trees are reduced in fecundity, and reproduction from the less infested trees is favored.

Uneven-aged Management

It seems to me we may be embracing the idea of uneven-aged management, wholesale, in our Northern Rocky Mountain ecosystems without a clear view of all its ramifications. We are still under legislative obligation to regulate our forests for the production of commodity (as well as non-commodity) outputs. Forest regulation commits us to sticking with the chosen management regime for a very long time and, if I am reading Forest Supervisors correctly, over very large, contiguous acreages. Uneven-aged management (especially single-tree selection) practiced according to this scenario, since it favors shade-tolerant species, has the potential for liquidating seral species over those acres. I trust we can all agree that this is a significant genetic consequence. By contrast, uneven-aged management has very little potential for liquidating shade-tolerant species, because they are very happy growing in the shade of a seral overstory.

Even if we agree to break up the uneven-aged acres with even-aged acres, uneven-aged management (especially single-tree selection) as we practice it in the U.S. has potential for dysgenic consequences. Instead of ascertaining the age of every crop tree potentially to be cut, we estimate age by measuring diameter, then cut to a diameter limit. We presume we are harvesting the oldest trees in an age class, but often we are unwittingly harvesting the biggest trees in a younger age class. Diameter-limit cutting has been likened to destroying the first, second and third place finishers in every horse race, then putting all the losers out to stud! In my opinion, we can't avoid this dysgenic selection until we are willing and able to ascertain the age of every crop tree potentially to be harvested, as is done in Europe wherever uneven-aged management has been successfully practiced.

Fire Exclusion

Evolutionists generally recognize random genetic drift as a potentially important generator of genetic variability. In the Northern Rockies, we cannot help but be impressed at the grand opportunity for genetic drift when we look at a time sequence of aerial photos following a major wildfire such as the Sundance Burn. In the initial photo we inevitably see small, relatively isolated islands of trees which have survived the fire, often by chance. In later photos we see the young

forest capturing the burned mountainsides until the entire landscape is again covered with trees---trees which have originated from the few parents in each of the surviving patches. To whatever extent we succeed in preventing or reducing the frequency of these sorts of fires, we will affect the influence of genetic drift, and may need to devise strategies to mimic those effects.

Non-Genetic Risks, Mack Trucks, Etc.

The surviving parent of a litter of six wolf cubs was killed by a truck somewhere near Ninemile last week. In 1980 in northern Idaho, the biggest killer of caribous was 18-wheelers. During the era of DDT, eagle embryos perished from thin egg shells. I think other factors than genetics which lead to the man-caused decline and extinction of species will "get 'em" long before inbreeding depression, depletion of genetic variation, selection, etc., will. If we take care that their habitats are in order and that they aren't shot up or run down by Mack trucks, they have enough evolutionary sense to keep themselves out of trouble genetically.

Climate Change

An exception to this broad generalization may be global climate change. The best hedge against disaster from climate change may be maintenance of healthy and genetically diverse forests, which may turn out to be the best argument for characterizing, cataloguing and conserving the genetic diversity of our forests, but more on this in the Summary and Recommendations.

Planning and Tree Improvement

Let's get this reforestation program in perspective. We have about 18 million acres of forests in the Northern Region. Forest plans schedule about 3.1 million acres for planting and maybe another 200 thousand beyond that could be considered for planting. So only about 18 percent of the forested land is scheduled for planting (another 4 million acres are scheduled for natural regeneration).

By 2010 virtually all the planting will be with genetically improved trees. Currently we plant about 7300 acres a year with genetically improved trees--about 4 million blister rust resistant western white pine trees. This genetic strategy for combatting an exotic pathogen has been less damaging to the environment and more cost effective than the ribes eradication program.

The genetic architecture of the selectively bred stands? Will be quite different from the native, wild trees they will replace. These stands will be improved in their growth and form, and, in some cases, improved in their insect or disease resistance. These stands will be composed of fewer genotypes but will exhibit a wider range of genetic variability and less inbreeding than their wild, native ancestors because they will be the products of matings between distant parents which could not have mated in nature. Most important, these stands will be exceedingly well adapted to the environments in which we plant them because they will have been carefully evaluated for adaptation in prior research and genetic evaluations. They will be well characterized and catalogued genetically.

Because these stands will contain few, sometimes related, families, we will recommend that they not be allowed to naturally regenerate at the end of the rotation. We will urge that they be harvested and replaced with an advanced generation of selectively bred trees further improved in these and other traits. We will also recommend that selectively-bred trees not be planted over thousands of contiguous acres.

Until we are planting only genetically improved trees, our planting stock will continue to come from seed collected from selected local stands and will be transferred according to guidelines developed from 25 years of local research into patterns of adaptation. These guides are already largely documented in the Northern Region Seed Handbook.

Summary and Recommendations

Know Your Species. You may have noticed the theme running through all the preceding sections: know your species, not just whether

it flies or runs or swims or is rooted, not just what it eats and what its reproductive habits are. But has it gone through frequent bottlenecks in its evolutionary history? Are you dealing with a population already inbred? How frequent is immigration? Is the management strategy you are devising consistent with the evolutionary history of the species?

The Rule of 50/500. A good rule of thumb, but don't be a slave to it, for it will sometimes lead you to proposing strategies which are inconsistent with the evolutionary history of the species. The rule of 50/500 may be the best guard against loss of rare alleles until we understand better how to deal with this issue.

Depletion of Genetic Variation. It's very unlikely to result from selection in native populations in the Northern Rockies. Keep an eye on inbreeding if your effective population sizes decline to 15 or 20 for more than one or two generations. And remember that even minor immigration will drastically reduce inbreeding. Recognize that inbreeding followed by rigorous selection in nature in the past has probably played a role in reducing genetic lode, but may be very difficult and risky to try to mimic in your management of wild populations; you must have assurance that your population will increase in numbers following the episode.

Changes in Means. Take yourselves very seriously here. The selections you make in the woods can change the average genetic quality of your forests, especially in the negative direction. Don't leave the sick, lame and lazy, even unconsciously.

Uneven-Aged Management. Let's intersperse the acreages of uneven-aged management liberally with acres of even-aged. Let's figure out a way to know the age of each crop tree in single-tree selection, and if we can't do that, then let's commit ourselves to planting trees of known high genetic quality to avoid genetic quality decline.

Fire Exclusion. This may turn out to be a non-issue, as we may never be able to prevent infrequent major conflagrations like the Yellowstone fires of 1988. If we do succeed, however, geneticists will need to try to devise a strategy for mimicking the effects of random genetic drift.

Non-Genetic Risks. Devote the bulk of your energies to figuring out how to minimize confrontations between Mack trucks and caribou (as an example); the caribou will always lose. There will always be more to do than you have time to do; attend to the non-genetic risks first.

A serious non-genetic risk may be global climate change. The Forest Service at large and this Region have begun initiatives to characterize, catalogue and conserve genetic diversity of forest trees. The Northern Region effort is the Ancestral Population Initiative, a program for finding, preserving, sampling and genetically characterizing populations of our forest trees across the ecological range in which they exist in the Region. This initiative is our counterpart to the system of Gene Resource Management Areas being developed for Regions 5 and 6. So, support your local geneticist!

Planting and Tree Improvement. Avoid planting thousands of contiguous acres with selectively bred trees. This may turn out to be a non-issue, as only about 18 percent of our forested land is likely to be planted. At the end of a rotation, do not allow a stand of selectively bred trees to naturally regenerate.

Conclusion

The healthy, productive forest is home for most of the species and resources you and I manage. Let's think of the healthy, productive forests as the seat of a three-legged stool supported by good geology (especially soils), good climate and good genes. The leg called genes is just as important as the other two. Let's keep all the legs stout.

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* * * *	**Wildlife and Fisheries**	* * * *

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Workshop 3A -- *List questions that need to be addressed in the management of wildlife biodiversity.*

BIODIVERSITY AND WILDLIFE MANAGEMENT

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An important aspect of managing for biodiversity is focusing on management of ecosystems and landscapes for a variety of wildlife and plant species, rather than simply focusing on a relatively small handful of species on an individual basis. Therefore, this presentation will emphasize the importance of old-growth forests and riparian habitats, the importance of maintaining landscape linkages for wildlife, and the maintenance of structures within stands that are of value to a wide variety of wildlife species.

On managing for the biological diversity of wildlife, it is important to manage those wildlife species and habitats that are most at risk, rather than simply managing for the total number of species or habitats. Wildlife species that are most at risk include species that are geographically rare (such as peregrine falcons), species that have large area requirements (such as grizzly bears), species with specialized habitat requirements (such as pileated woodpeckers), and species that are adversely affected by edge (such as forest interior birds). If our management were to focus on sheer numbers of species, the net effect could be to have a large number of widespread and opportunistic species such as starlings to the exclusion of more sensitive species such as the goshawk, pine marten, and pileated woodpecker. Habitats that are rare or special, such as old-growth or riparian habitats, should also receive special focus because of their value to a wide array of wildlife species.

Old-Growth Habitat

It is estimated that we have lost 85-98% of the old-growth forests that existed before European settlers arrived (Thomas et al. 1988), yet this habitat is extremely valuable habitat for a variety of wildlife species. Forty percent of the wildlife species in the Northern Region of the USDA Forest Service use old-growth habitat for reproduction or foraging (Harger 1978). Among the mammals in the Northern Region, old-growth components are thought to be preferred for reproduction or foraging by several species including the northern flying squirrel, boreal red-backed vole, woodland caribou, wolverine, pine marten, fisher, and several species of bats. Among the bird species occurring here, those that prefer old-growth include the northern goshawk, Vaux's swift, brown creeper, great-crested flycatcher, townsend's warbler, great blue heron, and several species of nuthatches, owls, and woodpeckers (Warren 1990).

Attributes of old-growth include large trees. These large trees are important as a substrate for foraging and are important in moderating the effects of extreme temperatures and wind. Vertical diversity of old-growth provides niches for a variety of wildlife species and supports lichens, which provide forage for large and small mammals. Snags provide cavities for nesting and denning and provide habitats for invertebrates, which are important as a food source for many wildlife species, and logs provide cover for wildlife species and habitat for invertebrates and fungi, providing a food source for mammals and birds (Warren 1990).

As resource managers, we are often asked to determine how much old growth is enough in a given watershed or project area. Based on a number of federal statutes including the Multiple-Use Sustained Yield Act, National Environmental Policy Act, Endangered Species Act, Resources Planning Act, and National Forest Management Act, Thomas et al. (1988) concluded that we are required to "maintain old growth in the amounts, stand sizes, and distribution to ensure the continued existence of potentially dependent wildlife species; to maintain existing plant and animal diversity; and to maintain the possibility of reintroduction of extirpated species on forests managed

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by the USFS." Thomas et al. (1988) state that it is uncertain how much more old-growth forest can be reduced and still meet our legal mandates. While we lack sufficient information on old-growth ecosystems and further research is needed, Thomas et al. advocate that we base our decisions on the best available data, considering the impact of forest fragmentation, the stability of remaining old-growth habitat, and the impact of possible large-scale disturbance, such as fire, on remaining old-growth habitat.

Old-growth forest is generally most productive, reaching greatest height and foliage density, when associated with riparian habitat (McClelland 1977). Because of this, it is valuable to retain old-growth forests in and adjacent to riparian zones. Christensen (1981) recommended retaining sufficient old-growth along riparian zones to fulfill territorial requirements of dependent species, rather than managing a narrow strip of forest along the riparian zone.

There has been debate over the ability to provide replacement old-growth forest from second-growth forest through silvicultural manipulations. According to the Society of American Foresters (1984), we do not currently have the knowledge to create replacement old-growth forest. Furthermore, due to the complexity of old-growth forest, we are unlikely to have the capability to reproduce a fully functional old-growth ecosystem in the future. Therefore, the Society advocates providing existing old-growth forest as part of the managed landscape. However, where existing old-growth habitat is insufficient to meet ecological needs or management objectives, or is lost due to catastrophic disturbances such as large-scale fire, there is no alternative but to assume we can recreate at least some of the components of an old-growth ecosystem (Thomas et al. 1988).

Edges

Edges are defined as the interface between plant communities or successional stages (Thomas et al., 1979). Creation of edge has been proposed as an important wildlife management technique in a variety of wildlife texts including Leopold (1933), Giles (1971), and Yoakum and Dasmann (1971), etc. This was based on the premise that many game species are adapted to edges, as are opportunistic species (those that are also adapted to urban and agricultural environments) (Noss 1983). However, many wildlife species decrease along the edge due to increased parasitism (by species such as the brown-headed cowbird), increased nest predation (by species such as jays), and increased competition for nest cavities (by starlings and other non-native species) (Gates and Gysel 1978; Brittingham and Temple 1983; Noss 1983). A study by Wilcove et al. (1988) indicates that the increase in predation due to edge-effect may extend as far as 650 yards from the edge. Disturbances by exotic plants, domestic animals, off-road vehicles, and poachers also increase along forest edges (Noss 1987).

Fragmentation

Fragmentation is the reduction and isolation of plant and animal habitat patches. Habitat fragmentation is generally considered to be the most serious threat to the maintenance of biological diversity (Noss 1987). Small, isolated wildlife habitat patches, such as disjunct old-growth stands, do not contain the full array of wildlife species that could be expected in larger blocks of habitat. There are several reasons for this. Among them are that large, wide-ranging species such as grizzly bears and wolves, tend to require large wildland areas (Schaffer and Samson 1985). Species such as Neotropical migrants, forest interior species, and open nesters may be vulnerable to the increased nest predation and parasitism and harsher microclimates associated with the increased edge effect of small habitat patches (Anderson and Robbins 1981; Whitcomb et al. 1981). Species that are fairly specialized, such as the northern goshawk or pileated woodpecker, are also susceptible to habitat fragmentation (Noss 1983).

The small, isolated populations that are associated with small, disjunct habitat patches are more vulnerable to catastrophic disturbances such as large-scale fire, disease epidemics, and severe weather conditions (Wilcove 1987). Small populations are very susceptible to demographic changes resulting from disturbances. For example, if a red-cockaded woodpecker colony already has a very low number

of reproductively active individuals, additional losses of reproductively active individuals, for example through hurricane damage to nesting trees, could have a devastating effect on the population. Similarly, if a grizzly bear population contains a low number of reproductively active females, then additional losses through fire or other catastrophic disturbance could bring the population below minimum viable population levels (Wilcove 1987). In addition to these problems are genetic problems, such as inbreeding, which can result in perpetuation of harmful genes or the inability to respond to environmental change (Wilcove 1987).

As a result of these concerns, where possible, wildlife habitat should be managed in stand sizes that: 1) are sufficient to retain microclimate characteristics, 2) minimize the negative effects associated with edge, 3) minimize disturbance from windthrow, and 4) are large enough to maintain breeding populations of the species that are dependent on them (Samson et al. 1989). Wilcove (1987) recommended that wildland areas should be sufficient in size to accommodate populations of the most area-sensitive species, which is also likely to accommodate species with smaller home range sizes. In addition, wildland areas should ideally be large enough to accommodate natural disturbance, such as wildfire, without being destroyed (Hunter 1990).

Where the possibility exists to design the shape of habitat patches, old-growth habitat patches should be somewhat circular in shape in order to minimize the ratio of forest edge to forest interior (Wilson and Willis 1975). In addition, timber harvest units (or other management impacts) located within wildland areas could be aggregated along the edge of the wildland area in order to retain the maximum amount of forest interior (Hunter 1990).

Corridors

Wildlife habitat patches can be linked by travel corridors to minimize the problems associated with habitat fragmentation and to encourage dispersal of wildlife between habitat patches (Harris 1984). Corridors can function as pathways for genetic interchange, for daily, annual, and seasonal movements, and for range extensions. There are two main categories of corridors as distinguished by Noss (1983). The first category is the line corridor (e.g., narrow stringers of trees, fence rows, etc.). Line corridors are of value in providing some security and shelter for travel by those wildlife species that will utilize them. Strip corridors are wider corridors that provide interior forest conditions (as opposed to line corridors). Where possible, strip corridors are preferred because they accommodate travel for a broader range of wildlife species and even provide habitat for foraging and reproduction for a number of wildlife species.

Corridors should be drawn into the overall resource management plan and should be designed to take advantage of landscape features such as riparian ecosystems and ridge systems (Noss 1983). As discussed previously, riparian habitat is an excellent location for the corridors, because of the inherent value of this habitat and the use of this zone as travel pathways by a variety of wildlife species. Studies indicate that riparian zones are used as travel corridors by a variety of birds and mammals, including passerines, carnivores, game species, etc. Noss (1983) recommends designing wildlife corridors along riparian habitats in conjunction with some of the adjacent upland habitat, wherever possible.

The appropriate width of the corridor will depend on the wildlife species in question, the purpose of the corridor, and the quality of the habitat within and adjacent to the corridor. For instance, an old-growth corridor surrounded by natural forest may not need to be as wide to function as an appropriate travel corridor as it would need to be if the corridor were surrounded by a clearcut. Noss (1983) recommends having as wide a corridor as possible in order to accommodate travel and some habitat needs of wildlife species. Noss goes on to point out that a corridor that is wide enough to provide suitable habitat will function to create one large wildland area out of two, otherwise separate, smaller wildland areas.

Corridors can be combined with buffer zones to design a landscape that provides high quality wildlife habitat intermingled with human land uses, with a minimum of conflict (Harris 1984; Noss 1987). This system involves having

a core wildland area buffered by a zone of low-intensity land use. Beyond this would be an outer buffer zone of moderate-intensity land use providing an additional buffer from the surrounding high-intensity land use areas.

Riparian Habitats

Riparian zones are extremely important as wildlife habitat. These habitats provide lush vegetation which in turn provides forage and shelter; horizontal and vertical diversity which provides abundant niches for wildlife; abundant invertebrates that are important forage for many bird and mammal species; water sources for drinking; friable soils for burrowing mammals; and microclimates with less intense temperature fluctuations and wind effects than the surrounding upland habitats (Doyle 1990; Borror et al. 1981; Roberts et al. 1977).

Many birds and large mammal species reach their highest densities in riparian habitat. My research in western Oregon indicates that many small mammal species are more abundant, live longer, are more reproductively active, and weigh more (perhaps indicating better body condition) in riparian habitats (Doyle 1990). Because of competition for wood products, recreation, grazing, roading, agriculture, and urban developments, the value of many riparian habitats has already been reduced.

Riparian habitat provides an excellent zone in which to design wildlife corridors. Streamside buffers are sometimes retained as narrow stringers of trees immediately adjacent to the stream. Which is effective in moderating water temperatures, but has limited effectiveness for providing wildlife habitat. Wider buffers are required to provide habitat requirements for a variety of wildlife species. Width of the riparian buffer should be based on factors such as management objectives, stream width, and topography, and the habitat requirements of the array of wildlife species.

It may be possible to conduct low-intensity timber harvest within the buffer zone while retaining important characteristics of the given habitat. The buffer zone approach discussed earlier could be used in riparian zones, such that the zone immediately adjacent to the stream receive no timber harvest, followed by an outer buffer zone in which light timber harvesting or other management activities occur.

Where possible roads should be avoided in riparian zones. If it is essential to build roads within riparian habitat, they should be built with the lowest width and clearing standards acceptable (Christensen 1981). Christensen recommended that roads should be located at least 200 feet from riparian habitat to protect the value of this habitat for wildlife (Christensen 1981).

Logs and Snags

Logs are important components of habitat for a variety of wildlife species and are particularly critical for feeding, reproduction, cover, and travel routes for small mammal species (Doyle 1987). In general, the more decayed logs have a greater number of niches for cover and have more abundant invertebrates and fungi for foraging. However, retention of logs in a variety of decay classes is valuable due to varied species preferences (Doyle 1987) and to provide a source of logs over a longer time period.

The larger logs are generally the most valuable logs because they provide superior cover and forage for a variety of wildlife species and remain intact for a longer period of time. Piles of slash, can also be used effectively as cover for small and medium-sized mammals and to provide pathways into the snow for species such as the pine marten which travel beneath the snow to forage and find cover during the winter months.

Snags are extremely valuable for a variety of wildlife species, particularly cavity-nesting species. In general, the large snags are most valuable because they are used by a greater variety of wildlife species. Large wildlife species, such as pileated woodpeckers, require large diameter snags, and even the smaller wildlife species generally prefer large diameter snags. Studies on the Flathead National Forest indicate that nearly all snag dependent species prefer snags with a DBH greater than 20 inches. It is also important to retain the larger snags because cavity nesters tend to nest at

considerable heights. Pileated woodpeckers, for example, tend to nest at 50 feet above the ground. Furthermore, retaining larger snags allows individuals of a variety of wildlife species to use a given snag. A single large snag may be used by a myriad of species including flying squirrels, chickadees, nuthatches, etc.

The species of snags that are retained should favor those that remain standing for a considerable time period and that are preferred by primary excavators. Christensen (1981) recommended retaining larch and ponderosa pine because they remain upright for long time periods (up to 50 years for larch) and generally rot from the inside out. In riparian zones, black cottonwood and aspen are especially important snag species.

The number of snags to retain per acre can be determined for some ecosystems through a model developed by Thomas et al. (1979). However, in the absence of sufficient information to run the model, a pragmatic approach may be to retain 2 to 4 large snags per acre well-distributed throughout the forest (Hunter 1990). Adequate distribution is important so that territorial competition does not prevent the effective use of a group of snags. In some instances, however, it may be valuable to aggregate snags. Cline et al. (1980) recommended aggregating snags and residual trees in the riparian zones and in the lower edges of timber harvest units, if necessary, for reasons of safety and fire control.

There may be circumstances in which it is valuable to leave high stumps in an area. Christensen (1981) noted that high stumps that have been left over from earlier logging activities are valuable foraging sites. Leaving high stumps may be a viable alternative if silvicultural treatments prevent leaving full-height snags.

As with logs, it is important to leave snags in a variety of decay classes. Although the older snags are preferred by many cavity-nesting species, the retention of more recently recruited snags provides a source of snags over a longer time period (Cline et al. 1980). To provide a continued source of snags, green trees that will eventually become snags can be identified and retained. Furthermore, providing large snags over several timber harvest rotations will probably require interspersing old-growth or long-rotation stands among the younger, more intensively-managed stands (Cline et al. 1980).

Alternatives

An interesting approach to landscape management that incorporates some of the aforementioned ideas has been proposed in Region 5 (Chapel 1990). In this proposal, there would be large forested areas that would be managed to retain components that are characteristic of old-growth forests (such as large woody debris, large diameter trees, etc.). Some of these old forest zones would be located in large blocks to accommodate wide-ranging wildlife species. These blocks of habitat would be connected to one another by old forest zones along riparian habitat and by corridors that cross ridge tops. The width of the old forest zones along riparian habitat would depend on the width of the steam and on management objectives but would generally be large (about one-half mile or larger in most areas). In this proposal, the old forest zones that were not being retained for special emphasis areas would be available for light timber harvest conducted in such a way that old-growth characteristics would be retained.

There would also be areas managed to provide young forest characteristics (e.g., high number of edges, and smaller trees). These zones would be managed to provide higher yields of timber and to provide habitat for quail, deer, and other edge-adapted species. Many of the concepts incorporated in this proposal would be useful in designing landscapes in the National Forests of the Northern Region as well.

Summary

In designing a landscape that incorporates management of biological diversity for a wide variety of wildlife species, some of the aspects that are important to consider are as follows:

Emphasize the wildlife species that are at greatest risk, for instance those that are rare, wide-ranging, sensitive to human disturbance,

or sensitive to edge effects, rather than simply focusing on the total number of wildlife species.

Establish a network of natural areas that contains representative samples of wildlife habitats and associated species.

Emphasize the conservation of rare or special wildlife habitats, such as old growth and riparian habitats.

Design landscapes that contain valuable wildlife habitats in size and distribution patterns that enhance the probability of long-term existence of wildlife species.

Maintain or create corridors to connect wildlife habitat patches.

Maintain one or more buffer zones around wildland areas that incorporate decreasing levels of intensity of land use with increasing proximity to the core wildland area.

Retain large snags and logs of a variety of decay classes.

Harvest timber in such a way that there are residual patches of green trees and brushy openings as well as snags and logs throughout the stand.

I would like to encourage people from all disciplines, wildlife biologists, silviculturalists, etc., to work together to design landscapes that incorporate sound wildlife management along with natural resource uses. I believe that good management for the biological diversity of wildlife is an attainable goal and that by working together, with our combined expertise, we will be able to achieve it.

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* * * *	**Inventory and Assessment**	* * * *

Session Chair: Rob DeVelice

Inventory and Assessment
Bob Szaro, W.O.
Ecosystems Research

Management for Landscape and Ecosystem Biodiversity
Wendel Hann, R.O.
Regional Ecologist

Workshop 4A -- *How should we measure and monitor biodiversity, e.g., for structural components and the landscape level?*

Workshop 4B -- *What important aspects of biodiversity are not being measured now and how should we measure them?*

* * * *	**Putting it Together**	* * * *

Session Chair: Sallie Hejl

Workshop Reports

Workshop 5A -- *What are the most important priorities in biodiversity for this Region?*

Wrapup
Arlene Doyle, R.O.
Wildlife Ecologist

BIODIVERSITY INVENTORY AND MONITORING

Robert C. Szaro
Ecosystems Research

Introduction

Biodiversity is an issue that often brings questions and confusion in any discussion (Evans and Szaro 1990, Szaro 1990). I have heard over and over again the questions: How can we define biodiversity? or What is biodiversity? To me these are simply nonsense questions. Intuitively we all have a base level of understanding of the meaning of biodiversity. We may not individually be able to come up with a textbook definition but there is no real mystery about it. When we have concerns for biodiversity we are saying we have a concern for all life and its relationships. As arguably the most intelligent species on earth we have a responsibility to try as much as possible for the continuance of all forms of life. What is biodiversity? Perhaps the simplest and at the same time most complete definition of biodiversity as formulated in the Keystone Biodiversity Dialogue Report is, "Biodiversity is the variety of life and its processes". Biodiversity means we must expand our view to encompass not just forests but riparian systems, ponds, alpine meadows, grasslands, and deserts as well. This includes more than vascular plants and traditional vertebrate species such as pocket mice, hummingbirds, spiny lizards, and native trout but also includes bees, butterflies, and fungi.

Inventory

It is almost mind-boggling to think about formulating an integrated, concise and relevant approach to inventory. In addition to the Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974 that requires an assessment of the renewable resources on all forest and rangelands in the United States at 10-year intervals, the Forest Service has at least 14 laws, 57 manual sections, and 20 national handbooks dealing with or touching upon resource inventories.

However we resolve this issue, there are some recommended broad principles outlined in the Keystone Biodiversity Report on the components of an inventory program. These include:

- The inventory should be hierarchical and "top-down" in the sense that landscape level assessments such as the Fish and Wildlife Service's "gap analysis" are used to identify priorities for inventory at the local level, and local assessments are used to identify priorities at the site level.
- The inventory should make maximum use of existing data management systems ...
- The inventory should be landscape based in the sense that abundance and distribution of plant and animal species are correlated with soils, vegetation, plant and animal community characteristics, and landscape features.
- The inventory at a minimum should include natural vegetation, all vertebrate and vascular plant species and at least some indicator species of non-vascular plants and invertebrates, and some indicators of other elements of biological diversity, such as sensitive communities or human-influenced processes and elements of structural diversity.
- Provision should be made for systematic inventories of all candidate, threatened, endangered, and sensitive species and for all other elements that are imperiled due to human activities or natural events.
- Inventories should be guided by an interagency master plan that coordinates acquisition of aerial photography, soil survey, vegetation survey, and vertebrate

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inventory that ensures compatibility of data within and among agencies.

- The above mentioned master plan should be implemented for all regional ecosystems and vegetation mapping and inventory of vertebrates should be completed within the next 10 years.

- The inventory should be compatible with, and feed information directly into, development and implementation of Geographic Information System (GIS) methodology, monitoring programs, and research activities.

- The inventory should provide the basis for determining species (including genetic level assessment), species groups, population guilds, habitats, landscapes or processes that require more intensive studies.

- Inventories should be coordinated with and make maximum use of the fifty state Heritage Program data bases, procedures and technology.

- The inventory process should identify levels or intensities of inventory that are appropriate for each level of planning, type of management activity or impact, type of land classification or degree of rarity or sensitivity of the element being inventoried.

- The inventory should have a strong element of quality control and assurance, including setting specific standards of accuracy and precision, timing the inventory to encompass the life-cycles of the target elements, standardizing methods and databases to the extent possible, and using trained personnel to conduct the inventories.

The need for more specific data and more efficient ways for collecting and managing data will lead to significant changes in the Forest Service inventory process. Changes being evaluated include use of methods and technology that will: 1) provide resource estimates for specific geographic units and evaluate the reliability of such estimates; 2) display estimates and units spatially; 3) make maximum use of existing information and new technology, such as remote sensing and geographic information systems; 4) provide a baseline for monitoring changes in the extent and condition of the resource; 5) eliminate redundant data collection, develop common terminology, and promote data sharing through corporate data bases; 6) utilize information management systems to provide maximum flexibility for data integration, manipulation, sharing, and responding to routine and special requests; and 7) provide up-to-date data bases using modeling techniques, accounting procedures, and re-inventories.

The advent of geographic information systems holds future promise for the development of a comprehensive biological information system (Davis et al. 1990). Much work and coordination will be involved to bring this to pass. We must keep in mind however, the need to continually check and update our database. It is not enough to set up the system and then use it without regard to the dynamics of ecological systems.

Monitoring

We all know about our legal and regulatory requirements for monitoring, but the true magnitude of the monitoring problem has yet to be fully determined. Monitoring must be viewed, like other aspects of forest plans, as a contractual agreement on the part of the Forest Service which must be met. Monitoring, obviously has the potential of being very costly and the demand, given forest plan requirements, has the potential to be overwhelming. Some method(s) of setting monitoring assistance priorities is needed. The current round of forest planning has resulted in a different monitoring plan for each National Forest. Many plans will clearly be ineffective and most are lacking in detail. This diversity in methodology and approach to the monitoring mandate will probably result in poor application, continuity, and a lack of quality assurance and quality control.

Our present concepts of monitoring vary depending on who is expressing them, their background, and the objectives of the monitoring being discussed. There is no well-defined policy at present on monitoring other than

the need to comply with the legal mandate and that there are three defined levels of monitoring. Implementation monitoring can, because of its purpose, often be accomplished by simple observation. The question being asked of implementation monitoring is, did we do what we said we would do? Effectiveness monitoring is intended to determine if the practices prescribed in forest plans actually performed as expected. Validation monitoring exists to determine if the standards providing a basis for prescriptions are valid. These levels correspond generally to the amount of effort and detail required to accomplish monitoring objectives. The more detailed monitoring also tends to be more quantitative.

There is a need for greater coordination, with considerable direction and standardization set at both National and Regional levels. Monitoring means different things to different people. Just what it is depends solely on monitoring objectives. This should suggest that we need to exercise great care to be explicit in what we say about monitoring. Just saying "monitoring", as if that single word is a solution to some of our problems, is not enough. We need to state our intent with some specificity.

Monitoring should provide sufficient information about the abundance of animals or plants targeted for monitoring to assure that current management practices are not threatening the long-term viability of their populations (Verner 1986). But viability concerns have added an additional layer of complexity to our monitoring problems, particularly when we try to derive a number for minimum viable population size. This theoretical concept espoused by Michael Soule' (1987) is useful from the standpoint that there probably is some minimum size population threshold that when crossed will lead to the demise of a species' population. The level of this threshold clearly varies with the species concerned, for passenger pigeons it probably was in the hundreds of thousands while for desert pupfish the number may be as low as 200. But as useful a concept as this may seem, in the real world it's close to impossible to determine minimum viable population size with any degree of certainty. There are too many variables involved, demographic viables such as immigration, recruitment, birth rates, survivorship, dispersal mechanisms, etc., catastrophic events, habitat loss and even changing climatic conditions. As an example, even with research efforts starting in 1972 and a total expenditures of $8 million dollars (Tilghman, personal communication) we still can't determine minimum viable population size for the Spotted Owl (Noon, personal communication). It is absolutely ludicrous to assume that we can determine minimum viable population size for every species on every National Forest. We may want to consider a more subjective approach, being that larger numbers of a species are obviously better fewer numbers of the same species. Maybe we should try to maintain species with as large a population size as practical.

Monitoring efforts are often severely hampered by the lack of prior planning and thought given to the desired results from any given monitoring effort. It is not enough to select a management indicator species, guild, or other monitoring target with the idea that this will allow us to assess the impact of any given management activity (Szaro and Balda 1982, Szaro 1986, Tilghman and Verner 1989). Ideally, the results from monitoring should feed back into the system to correct or fine tune management activities.

We should not waste our efforts on a monitoring system that fails to give the level of confidence needed by biologists to deduce the most likely effects of management activities on wildlife, fish or sensitive plant resources. In an era when mankind's activities are the dominant force influencing biological communities, proper management requires understanding of pattern and process in biological systems and the development of assessment and evaluation procedures that assure protection of biological resources (Karr 1987). It is essential that we strive to have our appraisals of these resources give us the ability to forecast the consequences of human-induced environmental changes accurately (Hoekstra and Flather 1986). But we have a long way to go in this process.

We must first have a clear understanding of our goals and objectives. The next step is to assess risk and assign priorities. We need to perform a kind of environmental triage. We must be able to say when enough is enough. With limited financial and physical resources

at our disposal, we may have to make the highly undesirable decision that we no longer will try to prevent the extinction of a particular species. Once we have determined those species and let's not forget the importance of ecological processes, we need to formulate the types of questions that need to be answered to determine that we are meeting our goals and objectives. It is absolutely critical to ask the right question in the first place. Why monitor shade cover over perennial streams in order to maintain water temperature for trout when directly monitoring stream temperature is a more appropriate measure. Thus, our efforts will be geared to maintaining as much shade cover as needed to maintain water temperature.

Specifically, there are several major monitoring concerns: 1) legal challenges to National Forest System activities and their monitoring; 2) how to assure that monitoring is adequate in terms of what is being measured; 3) how much data and how to handle the large volume of data being collected; and 4) are the measurements accurate.

A single national forest may contain several hundred species of vertebrates, a thousand or more species of vascular plants, and an unknown number of invertebrates, fungi, and bacteria. Even under the most optimistic scenario of funding and staffing, the Forest Service can monitor only a small proportion of these species--hence the use of such things as management indicator species. The use of management indicator species has several critical problems: 1) the selection of the wrong species as indicators; 2) the selection of too few indicators for a forest; 3) the failure to use plants, invertebrates, and even habitats as indicators; and 4) and perhaps most important of all, the lack of any real correlation between management indicator species and the other species or groups of species they are supposed to indicate (Szaro 1986, Patton 1987).

Moreover, even if the management indicator species approach was workable it could only be effective when accompanied by an adequate monitoring program--which most are **not**. Such a program must consist of: 1) a scientifically sound method for assessing populations of the management indicator species in question; 2) a reasonable frequency of measurement; and 3) a predetermined population or degree of change in population size, density, or dispersion that triggers a reanalysis of management activities. I cannot emphasize the latter point strongly enough. Forest projects and plans must incorporate monitoring as an integral part of all management actions. The plans should be written in such a way that that management responds to the feedback information provided by the monitoring program without, yes without, forest plan amendment. Forest plans can and should be amended whenever the evaluation of monitoring data indicates such a need. But the best way is to establish a threshold in the plan that allows for the three possible responses to management activities; i.e., populations either rise, remain stable, or fall. At the present infant state of most monitoring efforts, few programs, as described in National Forest plans meet all these requirements.

Monitoring should also have a strong element of quality control and assurance, including setting specific levels of accuracy and precision, timing the inventory to encompass the lifecycles of the target species, as much as possible, and standardizing methods and databases for all Forest Service organizational units, especially when monitoring the same species. However, whatever is done must be as cost-effective as possible. Some possibilities are risk analysis, increasing the scope of monitoring efforts, and determining the needs of monitoring objectives. We might want to limit direct monitoring only on high risk species, on a priority basis, while relying on habitat relationships for most other species. Monitoring efforts should be spread over as large a geographical base as possible (and feasible) to reduce the cost per forest and to increase the scope of applicability. Whenever possible, monitoring should only be asked to detect **declining trends** because of the potential cost savings (almost 90%) (Verner 1986).

Along with this is our need to develop a quality control and assurance program that ensures: 1) objectives are measurable (and thus monitorable); 2) appropriate measurement techniques and procedures are being used; and 3) management thresholds are clearly identified and incorporated into the planning process so

that, if crossed, they automatically trigger a reanalysis of the planned activities.

The quantitative aspects of monitoring impose problems in quality control and assurance that seem particularly perplexing. The first, and most obvious, is statistical validity or in other words quality control. Forest plans probably will not require monitoring of features where there is little or no disagreement. With disagreement there is likely to be challenge. With challenge, data validity and statistical design become important. Any time quantitative data is collected, its validity is a potential issue. Observer, seasonal, or annual variability all contribute to potential sources of bias or error. We must develop monitoring systems that allow for differences or at least control for these sources of error. It is also important that the protocols are rigidly followed once the monitoring process has started. Monitoring protocols **cannot** be subject to whimsical changes if we hope to have any faith in our data. We cannot allow each biologist on each forest the luxury of reinventing monitoring protocols with each and every changing of the guard. Once started we have two and only two options: 1) continue the monitoring program or 2) end the monitoring when our need are met. Any other option invalidates our efforts and **wastes** all prior data and the expenditures involved in the collection of those data. It is highly desirable that, if at least regionally, monitoring plans for the same species in the same habitats be consistent. This has two clear advantages: 1) people moving from one forest to another will not have to relearn monitoring protocols with every move; and 2) most importantly, we will be able to more successfully defend our actions and decisions both in appeals and in litigation.

The second problem area is that of quality assurance. This is in some respects similar to the statistical problems just mentioned. There is enough difference, however, that it needs some recognition on its own. Quality assurance is a process whereby data quality is defined, not a process that forces data to meet a particular standard. The data quality needs to be sufficient to meet the purposes defined for its collection. Quality assurance is simply a process of establishing and documenting what that quality is. Quality assurance deals with such concepts as precision, accuracy, comparability, representativeness, and completeness of the data. Environmental issues seem to be ever more contentious in the public arena. This trend is likely to make data quality assurance much more important in the future.

But there are some very fundamental questions we need to answer about monitoring. How do we determine what, where, how, when, and why to monitor? The answer to all of these should be determined in the project (and hopefully will reflect the forest plan) planning process. Monitoring is an integral part of any project and its costs should be included as part of the project. Not enough money to include monitoring--then we must seriously question whether we have the appropriate level of funding to do the project in the first place.

What do we measure? That depends on our goals and objectives--we might look at the presence or absence of species across the landscape, measures of change in diversity, species richness, genetic variability, a whole litany of possibilities (See Magurran (1988) for a good discussion of measuring ecological diversity). Biodiversity is **not** a single entity with the possibility of us deriving a simple index of increasing or decreasing biodiversity (Salwasser 1990).

Where do we measure? This depends on the scale and scope of the project, but let's not lose sight of context considerations.

How and when to measure are more technical questions that Forest Service Research and university cooperators can certainly help with.

And finally, Why to Monitor? We don't monitor only because we have a legal mandate to do so, but because we are unable to predict with any certainty the long-term and even short-term consequences of many of our management activities.

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MANAGEMENT FOR LANDSCAPE AND ECOSYSTEM BIODIVERSITY

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Abstract

Management for landscape and ecosystem biodiversity provides a system for biodiversity conservation. This paper presents basic concepts and an overview of important aspects of resource management in relation to conservation of ecosystem and landscape processes. Examples of the cost of system disruption and rehabilitation are used to exemplify the need to manage our ecosystems and landscapes within the processes and cycles they have adapted to during evolutionary time. A brief review of losses to biodiversity, and goals and objectives of biodiversity conservation are provided. A basic process is given for ecosystem management, that provides for conservation of biodiversity, while achieving production of an array of resource products and values.

Introduction

This paper provides an overview of ecosystem and landscape management concepts and philosophy in relation to resource management and conservation of biodiversity. It is my philosophy that all people have a responsibility to "their world"; to take part in its management, for sustainable ecosystems that will provide habitat for all biota, including mankind. In my opinion all biota have a right to a place on earth. If we believe in the ecosystem concept and the "web of life", it is a must that we manage to maintain the integrity of the "web", by maintaining the "threads". I hope this paper provides some insight or information that will help us conserve biodiversity.

Concepts

Ecosystem management is the treatment of the biotic community with its associated land, air, and water to produce an array of desired resource products and values, while sustaining biotic and abiotic potentials and their interactions and processes. This treatment not only includes active treatments, such as timber harvest, livestock grazing, roads, prescribed fire, or a recreational campsite, it also includes passive treatments, such as succession to an older community with more fuel material, wildfire, or insect and disease mortality. It is important that we remember that ecosystems are dynamic and often change rapidly through growth, or interactions with processes, such as weather, fire, or landslides.

An ecosystem "is the sum of the plant community, animal community, and physical environment in a particular region or habitat (Barbour and others 1980)." I offer a definition that places an emphasis on processes. This definition of an ecosystem is "the biotic community and associated land, air, and water environment, and the interactions with processes of energy exchange." Processes of energy exchange that dominate in the northern Rocky Mountains and Plains include: 1) plant growth and death with associated successional dynamics; 2) fire; 3) the biotic food chain; 4) weather, including both severe and average events; 5) the hydrologic cycle; 6) landslides and mass flow; 6) snow avalanche; and 7) the soil-biotic nutrient cycle. Ecosystems are described relative to composition, structure, and function and how these attributes interact with processes and change over time. Composition includes the amount of various species, their size, age, and condition classes, and the amount of various physical attributes of the land, air, and water. Structure is the relationship of size and distribution of the various biotic and abiotic components. Function is the role that a various biotic or abiotic attribute plays within the ecosystem.

Ecosystems have developed over geologic time in response to changes in the physical environment and over adaptive evolutionary time to changes in the biotic environment. These changes have been a complex interaction

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between the biotic and physical environments, since the initiation of biotic life on earth. This dynamic system of change over time can be conceptually organized into 1) primary dynamics and 2) secondary dynamics. The factors of primary dynamics relate to the development of ecosystems from an initial state of relief and parent material (Jenny 1958; Jenny 1980). Throughout this time fluxes in the organisms and climate available to the site contribute to changes in development, along with development due to interactions of biota with physical and chemical site factors. At the present point in time the components of the ecosystem, i.e. biota, soil, hydrologic system, air, and landforms, are a result of this development over time. Changes in the ecosystem that are a result of secondary dynamics are those relatively short-term changes caused by interactions with energy exchanging disturbance processes. After a disturbance, such as fire, the system develops until it becomes relatively stable. This point of relative stability is considered the end point of succession, often referred to as the climax community (Major 1951). Due to the dynamics of low level energy exchange processes (such as insects and disease or weather), shifts in climate, influxes of new species, extinctions of species, and adaptation of species to better compete, this point is essentially an abstract concept. However, having an understanding of the direction an ecosystem will develop following a disturbance, and what species will dominate, will help us predict the types and rates of ecosystem change following a disturbance, such as fire, or a management treatment, such as timber harvest or livestock grazing.

Each kind of ecosystem has a "type" of community, soil, hydrologic regime, climate, and landform. The description and characterization of various types of ecosystems is classification. Ecosystem classification is a hierarchial process, depending on the amount of variation included in a given type. The level of classification depends on the objective of a given assessment and the interpretations that are to be developed for the assessment. In the Northern Region we use community classification for existing communities, potential vegetation/ site classification for ecosystems, and soil taxonomy for soil classification. Maps are developed from classification by describing repeating map units, which are combinations of types of communities or ecosystems that typically occur together and have similar interpretations and response to management. It is important to understand that ecosystems and ecosystem classification and mapping references a "kind" of community and environment that occur scattered throughout a large geographic area, wherever that situation exists. Thus, on a map a "kind" of ecosystem can occur in many different map polygons.

A landscape is "a heterogeneous land area composed of a cluster of interacting ecosystems that are repeated in a similar form throughout (Forman and Godrun 1986). Consequently, a landscape is one contiguous area, and on a map would be one polygon. The size of the landscape or polygon depends on the objectives of the assessment and the amount of variability that can be accepted in the interpretations for the assessment. Landscapes can range from areas that encompass two continents, when evaluating tropical to arctic migratory birds, to an area that is only a few acres in size, when evaluating nutrient cycling in a specific environmental setting. Table 1 provides a tabular comparison of landscape and ecosystem levels. Table 2 provides landscape assessment levels with typical interpretations and scales for map assessments.

Landscapes are also described in the general areas of composition, structure, function, connectivity, and processes. However, these terms have a different interpretation at the landscape level. Composition is the kind amount, size, and shape of different landscape elements, or ecosystems. Structure is the distribution of materials, species, and energy in relation to the composition of the landscape elements (Forman and Godrun 1986). Function is the interaction among the landscape elements in relation to the flow of species, materials, and energy. Function specifically relates to connectivity and corridors. Connectivity is a measure or assessment of how continuous a network of travel linkages, corridors, or adjacent landscapes are, for a given species. Processes are the energy exchanging disturbance regimes or cycles that often result in change. This is the same interpretation as ecosystem processes.

Table 1. Landscape Map and Ecosystem Classification Levels

Landscape Map	Ecosystem Map Unit	Potential Community	Soil Taxonomy	Existing Community
Continent(s)	Province Group	Formation Group	Orders	Lifeform Group
Physiographic Province	Physiographic Province	Formation	Suborders	Lifeform
Subprovince	Section	Series	Great Groups	Life form/ Size_Age Class
Biogeographic Area	Subsection	Broad Habitat Type Groups	Subgroups	Cover Type Group Size_Age Class
River Basin Watershed	Broad Landtype Association	Habitat Type Groups	Families	Cover Type Group Size_Age Class
Main Stream Watershed	Landtype Association	Habitat Type or Group	Families or Phase	Cover Type Size_Age Class
Community/ Site	Landtype or Landtype Phase	Habitat Type or Site Type	Series or Phase	Dominance or Community Type

Table 2. Landscape Assessment Levels and Interpretations

Landscape Level	Scale	Assessment Level	Example Interpretations
Continent(s)	1:10,000,000 -1:5,000,000	International National/Regional	Species Viability, Climate
Physiographic Province	1:5,000,000 -1:1,000,000	National/ Regional	Major Animal Species, Vegetation Types, Key Animal Travel Linkages
Subprovince	1:1,000,000 -1:500,000	Regional/ Forest Plan	Travel Linkages, Diversity of Types, Representation of Size_Age Class
Biogeographic Area	1:500,000 -1:250,000	Regional/Forest Plan Integrated Resource Assessment	Travel linkages, Corridors, Fragmentation, Representation of Types, Processes, Function
River Basin Watershed	1:250,000 -1:100,000	Forest Plan/Integrated Resource Assessment	Corridors, Fragmentation Types, Hydrologic Regime, Succession
Main Stream Watershed	1:100,000 -1:24,000	Integrated Resource Assessment Project Assessment	Corridors, Fragmentation Types, Hydrologic Regime, Composition, Structure
Community/ Site	1:24,000 -1:5,000	Project Assessment	Composition, Size_Age Class Structure, Function, Productivity, Products

A typical landscape is made up of three basic types of landscape elements (Forman and Godrun 1986). These are patches, corridors, and a background matrix. A patch is a nonlinear landscape element differing in appearance from the surrounding elements. A corridor is a narrow, strip or linear element that differs from the elements on either side. The background matrix is the most extensive and connected type of landscape element, and typically surrounds patches.

Forman and Godrun (1986) give several principles of landscape ecology that relate specifically to biodiversity.

> Landscape heterogeneity decreases the abundance of rare interior species, increases the abundance of edge species and animals requiring two or more landscape elements, and enhances the potential total species coexistence.
>
> The expansion and contraction of species among landscape elements has both a major effect on, and is controlled by, landscape heterogeneity.
>
> The flows of heat energy and biomass across boundaries separating the patches, corridors, and matrix of a landscape increase with increasing landscape heterogeneity.
>
> When undisturbed, horizontal landscape structure tends progressively toward homogeneity; moderate disturbance rapidly increases heterogeneity, and severe disturbance may increase or decrease heterogeneity.
>
> The rate of redistribution of mineral nutrients among landscape elements increases with disturbance intensity in those landscape elements.

When relating these basic principles relative to assessment of biodiversity in a given landscape, it is important to remember that heterogeneity or homogeneity, is neither good or bad. If we are managing for relatively natural landscapes and conservation of biodiversity, the variability in heterogeneity, across both time and space, should be somewhere in the realm that the ecosystems and landscape evolved in over adaptive time. The importance of the basic principles listed above, is the ability they give us in providing measures and predictors, in order to assess various landscape patterns relative to resource management alternatives and associated effects on elements of biodiversity.

Biodiversity has been defined by multiple authors (Reid and Miller 1989; OTA 1987). From a management and assessment viewpoint I define it as "the variety of biotic communities, species, and genes, and their interactions with ecological processes and functions, within ecosystems and across landscapes." This definition provides insight into the multiple levels of biodiversity. Conservation of species alone is not enough. The finer level of gene conservation and the coarser levels of ecosystem and landscape conservation are equally important.

Importance of Biodiversity in Resource Management

There are three general areas that are important relative to biodiversity and resource management. These are: 1) the importance to mankind of our biotic legacy, both spatially and in time; 2) the dynamics of ecosystems in time and space; and 3) system cycles and connections, and the high cost of repair of cycles or connections once they have been broken. A brief discussion of each of these general areas follows.

Our biotic legacy are all the species of biota that live on the land surface, in vegetation, in soil, in air, and in water. These species occur both across space and time. They occur at a given time across a variety of landscapes. They occur across time as they are associated with various successional stages of communities associated with disturbance regimes or time of recovery from disturbance. Due to loss of habitats in various landscapes, many species spatially are becoming extinct. But even more troublesome, are the species of plants and animals that have evolved a strategy of lying dormant and waiting for a given disturbance event to stimulate growth and reproduction. If this event does not happen within the period they can remain viable, they are lost, and we may not even be aware of their possible extinction. This is why it is so important that we pay attention to landscape

and ecosystem processes and change through time, as well as the present composition, structure, and function.

The biotic legacy of species is extremely important to maintaining our options and productive potential for resource management. However, there are broader benefits to mankind than the relationship of biotic species diversity to resource management. The use of genes from native species for agricultural genetics is a new and emerging field with some major successes and great promise for the future. Many of our native species, both plant and animal, have genes or biochemicals that can be spliced into agricultural crop species or developed in other ways that improve productivity or reduce susceptibility of crops to insects and disease.

A similar area of development is the biomedical industry. Many plant and animal species contain natural chemicals that can be used, or synthetically developed once they are tested and analyzed, to treat diseases in humans or other animals. Both the agricultural and biomedical industry are in their infancy relative to testing native species. I would estimate that less than one percent of our native species have been tested for these uses. This has major ramifications, both economically and socially, and behooves us to conserve the genetic and biochemical variability of all biotic species.

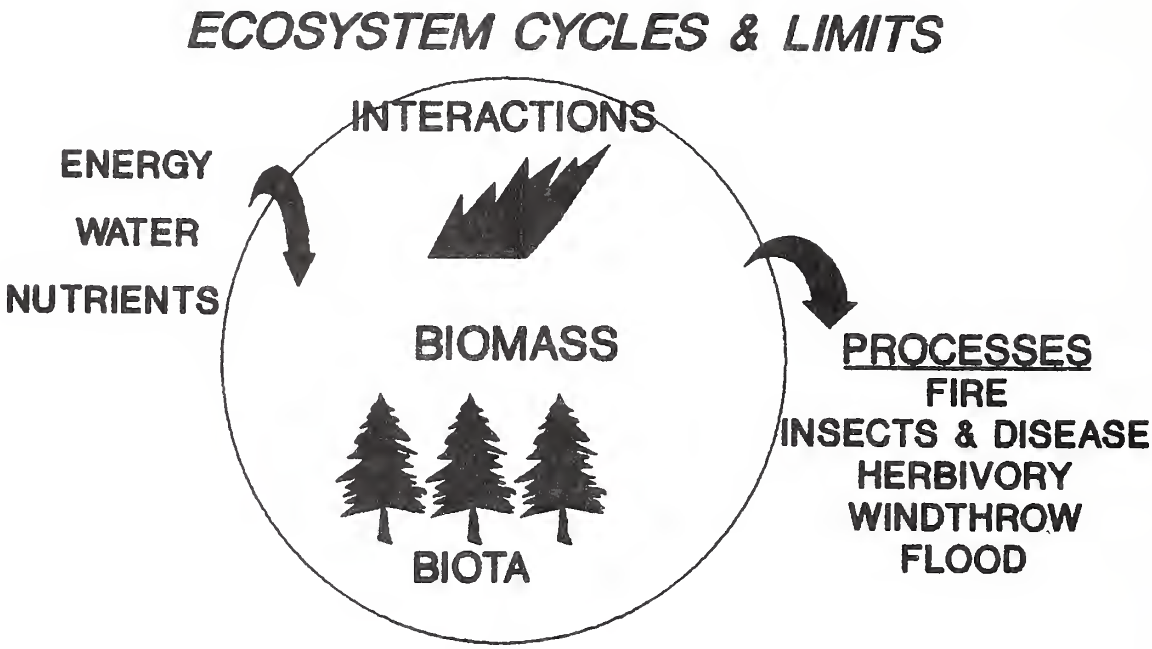
The second general area relative to importance of biodiversity to resource management is the dynamics of ecosystems across time and space. One of the major misconceptions, both with the general public and with many resource managers, is "what you see today will always be if we leave it alone." If we consider the basic ecosystem energy exchange processes we know that this cannot be the case. In fact, the one principle that is guaranteed is that "ecosystems will change across space, in response to the effects of disturbance, and will change through time in response to growth, death, and effects of low level chronic disturbance." This basic cycle of biomass production and cycling through energy exchange processes is depicted in Figure 1.

Ecosystems of the northern Rocky Mountains and Plains are relatively productive. On the average these ecosystems produce about one ton per acre per year of biomass. Approximately 25 to 50 percent of this biomass is converted from live to dead biomass per year. In our ecosystems, because of relatively short, cool growing seasons, rates of decay are slow. The total biomass, both live and dead, is consumed through decay and herbivory at rates that range from 25 to 50 percent per year. We can conclude with simple logic that in most of our environments there will be a steady accumulation of dead and live biomass through successional time.

The major process for this cycling in the northern Rocky Mountains and Plains is fire. These ecosystems will be dynamic and change in composition and structure over time, since the last fire, and when they accumulate enough biomass, they will once again be cycled by fire. Man can manage this cycle through use of prescribed fire, timber harvest, and grazing to reduce fuels. However, we should admit that wildfire will be a fuel management alternative. The one unrealistic alternative is to think we can draw a line around an area, and state that we will eliminate wildfire no matter how much fuel accumulates. This is a common strategy for management to meet goals for wildlife or watershed cover, on a short-term basis. These types of situations also occur commonly where past timber management treatments were not in concert with ecosystem processes, such as highgrading of open ponderosa pine stands and conversion to multi-layer budworm and mistle-toe infested Douglas-fir. When we select any of these management alternatives, which result in large areas of continuous, heavy fuels, in ecosystems that naturally cycled at faster rates with fire, we must also accept that productivity will decrease and when fire occurs the effects will be at much more intense levels than to which these ecosystems are adapted. The results are bound to be negative to biodiversity when all aspects are considered.

The third general area of importance of biodiversity to resource management also relates to Figure 1 and the cycles, limits, and connections of ecosystems. The cycles and connections are complex because ecosystems and landscapes have many attributes and elements. All attributes and elements are linked in some way, but some linkages, when broken, cause major disruptions of the system. An example of this type of complex linkages follows.

Figure 1. Ecosystem Cycles



Whitebark pine grows in high elevation ecosystems. This tree is fire dependent on a relatively long fire interval. The mature trees produce cones that have nuts. These nuts are gathered by squirrels that deposit them in "midens." Bears and other animals feed on these midens of nuts as an important fall food source. This is very true for the grizzly bear and in years of poor nut production, there has often been a correlation with higher grizzly bear - human encounters, because the bears are roaming farther for food. The nuts are also gathered by the Clark's nutcracker and deposited in clusters in the soil surface, typically in an opening. The nutcracker returns to many of these sites to feed at later dates. However, many of the seeds remain and germinate to provide for regeneration of whitebark pine trees. In fact, the only predominant regeneration strategy for most whitebark pine communities, is planting of the nuts by the nutcracker in recently burned areas. Since settlement by European man, several factors are causing a rapid reduction in whitebark pine and negative effects on associated species, such as grizzly bears. Fire control has eliminated many of the regeneration areas that would have naturally occurred. The introduction of blister rust, which is an exotic that infects and causes mortality in both white pine and whitebark pine, is also causing reduction of whitebark pine. The combination of the two man-caused effects is having major negative effects on whitebark pine and associated linkages to other species and attributes important to biodiversity in these ecosystems.

The cost of disruption of cycles and connections is high. Costs are not only the loss of biodiversity, related to opportunities lost for resource management, biomedical uses, and agriculture, but costs can be direct in terms of recovery of species or restoration of systems. Common examples of losses and costs to biodiversity follow:

1. Loss of species populations due to habitat loss. Millions of dollars are typically required for purchase and restoration of habitat that could have been avoided if we would recognize and manage the habitat prior to isolation and loss of species populations.

2. Loss of species due to mortality. Millions of dollars are required to recover a species,

such as grizzly bears and wolves, once their populations have been reduced below a viable level due to man-caused mortality. It would be much more efficient to manage the populations prior to isolation and loss.

3. Many of our riparian systems were beaver pond systems that were relatively stable. Through extensive trapping of beavers, which eliminated the environment for shrubby riparian communities that provided streambank protection, followed by heavy livestock grazing, these systems are now in an unstable, unprotected, downcutting regime. The costs of restoration are usually thousands of dollars per acre. It is much more efficient to manage trapping and livestock grazing to maintain these ecosystem in a stable condition.

4. Traditional timber harvest and site preparation practices have not represented the effects of natural processes, such as fire and succession. Older age classes have been lost, as well as park-like, fire maintained stands, early seral stages with high amounts of dead standing, and seral stages dependent on certain kinds of fire effects. The cost of restoration of the amounts and patterns of these successional stages is high and many cases is unobtainable except over a long-term period. Certainly, we should start now doing what we can to repair impacted areas and better represent natural processes and conditions in new areas of development.

5. The placement of extensive, high impact road systems has caused major negative effects on species movement and the hydrologic system. While most of our practices, such as timber harvest and grazing, are temporal on the landscape, permanent road systems have a permanent, usually negative effect on landscape and ecosystem biodiversity. It is extremely important that we manage our road system to reduce effects and remove and restore areas where roads are not needed. The use of temporary access and alternative harvest methods is a must if we are to maintain biodivesity and not permanently fragment landscapes.

6. A major passive effect that is often very negative to biodiversity is the introduction of exotic species. Exotic species, both plant and animals, are usually introduced without their native parasites. This makes them much more competitive than our native species. Also our native species have not adapted to their competitive strategies. The negative effects of exotic species, such as starlings, blister rust, knapweed, leafy spurge, burros, feral horses, etc., have been well documented. It is essentially impossible to eliminate most exotic species once they have been introduced, and the cost of control to reduce impacts is excessive. We must have comprehensive strategies to avoid introduction and spread of exotic species.

7. Earlier discussions in this paper have referred to the effects of fire suppression and removal of the fire process. This effect is typically passive and the results are not obvious to many people, both lay public and resource professionals. Yet in terms of effects on biodiversity, this has been one of the most far reaching factors relative to removal of an ecosystem and landscape process. The fire process has been a keystone process relative to adaptations of many northern Rocky Mountain and Plains species. There is little doubt that the loss of this important process in many ecosystems is having a domino effect, both spatially and in time. The cost of reimposing fire on many landscapes that now have unnatural fuel conditions is high, often ranging from $200 to $500 per acre. However, the alternative of waiting for wildfire to manage these fuels, and having the resulting high intensity effects and potential loss of resources and property, is also a high cost alternative.

It becomes fairly obvious when looking at these various losses and the cost of recovery and restoration, that there are great benefits in managing the systems and species prior to loss of biodiversity attributes.

Biodiversity Conservation

In order to look at goals and strategies for conservation of biodiversity, it is important to

summarize the major losses that are occurring. General areas of losses to biodiversity in the northern Rocky Mountains and Plains follow.

1. Loss of native plant or animals species or genetic types.

2. Addition of exotic plant or animal species.

3. Loss of site potential due to soil loss or permanent shift in hydrologic regime.

4. Removal of process, such as fire, that is key to the energy cycle.

5. Lack of successional stage representation present through adaptive time.

6. Change or loss of environmental linkages.

7. Loss of biotic corridors or linkages.

8. Change in community size, shape, & pattern from natural variation.

In order to avoid these losses to biodiversity we can develop some basic goals for biodiversity conservation. These follow:

1. Conserve the native biotic resource and avoid introduction of exotic species.

2. Conserve the basic soil, water, and air system and quality.

3. Conserve ecosystem and landscape processes in time and space.

4. Conserve natural landscape patterns in time and space.

There is a basic ecosystem management process we can implement to achieve these goals. This is a stepwise process that emphasizes understanding and designing treatments to maintain ecosystems and landscapes, while producing an array of products. This system is logical and will result in sustainable ecosystems. The basic steps are listed below.

1. Characterize the site potentials, existing conditions, and opportunities for treatment.

2. Characterize the ecosystem processes, connections, and limits.

3. Characterize the landscape patterns, linkages, and corridors.

4. Assess the basic ecosystem and landscape attributes relative to the variation they experienced through adaptive time.

5. Identify specific species or populations and other conditions that are outside limits relative to conservation of biodivesity and develop recovery or restoration strategies.

6. Synthesize interpretations from steps 1 through 5 to develop a set of treatments for a landscape area. Emphasize implementation of treatments to reestablish processes, to change composition due to risk/stress, to establish linkages/corridors, to conserve native species, to control exotics, and to conserve soil, air, and water quality. From these treatments a given range of products will be produced.

7. Identify treatments to produce additional products and values that fit within representation of ecosystem and landscape composition, structure, function, and processes that occurred through adaptive time.

8. Involve and interact with both internal and external publics, throughout the process, to assess expectations, outputs, and alternatives.

Summary

In this paper I have attempted to give a broad overview of ecosystem and landscape biodiversity and the relationship to resource management. We are at a time when our environment both economically and environmentally is a world environment. The relationship of resource management, economics, and urban development with resource use is a complex web. We will not be able to maintain habitats for mankind unless we ecologically manage our environments within the context of this web.

The value of Wilderness and other natural areas in providing centers for conservation of species, processes, and examples of natural systems is evident. Of equal importance are the lands we chose to manage for production of resource products and values. The closer we can manage these lands to naturally functioning landscapes and ecosystems, the better we can achieve an overall goal of conserving biodiversity. We all have a responsibility to "our world." We can each individually make a difference by contributing to the "whole." I hope you chose to make that difference and I hope the information in this paper is a contribution to the effort.

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****	Workshops	****

Workshop 1A -- What Considerations are Important in Dealing With Fragmentation?

Workshop 1B -- How Do We Establish Baseline Conditions to Measure the Success of Landscape Management?

Workshop 2A -- How Do We Manage for Special or Limited Habitats (Such as Riparian and Old-growth)?

Workshop 2B -- How Do We Manage for Important Structural Components Within Harvested Habitats?

Workshop 3A -- List Questions That Need to be Addressed in the Management of Wildlife Biodiversity.

Workshop 4A -- How Should We Measure and Monitor Biodiversity?

Workshop 4B -- What Important Aspects of Biodiversity are not Being Measured now That We Should be Measuring (and can Realistically Expect to Measure) and How Should We Measure Them?

Workshop 5A -- What are the Most Important Priorities in Biodiversity for this Region?

Workshop 1A

WHAT CONSIDERATIONS ARE IMPORTANT IN DEALING WITH FRAGMENTATION?

General

Minimize fragmentation to maintain future options.

Restore landscape linkages where fragmentation has occurred.

Maintain viable populations and landscapes.

Assess secondary impacts of disturbances resulting from fragmentation (e.g., weed/exotic encroachment, poaching).

Determine desired future conditions and amend or update forest plans as necessary to provide for desired future conditions. Adjust standards (e.g., 40-acre opening).

Assess landownership patterns and private values/goals vs. federal values/goals.

Patch Size

Fragmentation results in loss of interior forest environment.

Fragmentation reduces habitat for species with affinities for interior forest environments.

Fragmentation increases edge effects and thus favors edge adapted species.

Leave biggest blocks possible.

Patch Configuration

Fragmentation alters natural landscape patterns (e.g., juxtaposition of different community types).

Fragmentation results in isolation of interior forest habitats.

Corridors

Locate existing migration corridors and assess the connectivity of similar ecosystems.

Assess corridor width and redundancy.

Assess the long term integrity of corridors, reserves, and patches.

Roads

Roads cause habitat loss, are barriers to migration for some species, increase the vulnerability of some species (e.g., to poaching), and increase access to exotic encroachment (e.g., spotted knapweed).

Frequency of entry should be reduced via effective road closures.

Reduce road density.

Scale Issues

Need to manage across a broader land base (variable scale; e.g., project, landscape, forest, regional).

Use tiered approach: small, medium, and large scale.

Identify which time scale to use (e.g., single project, 10-year plan, rotation, multiple rotations).

Threatened, Endangered, and Sensitive Species and Special Habitats

Habitat needs of TES species may be threatened by fragmentation and need to be considered.

The location, size, and condition of special habitats, sensitive species, and communities should be documented.

Fire Considerations

Re-examine fire control policy (e.g., allow let-burn in large landscapes; manage with fire).

Emulate the inherent diversity patterns from a natural fire regime.

Silviculture

Implement more uneven-age management.

Manage for replacement stands (all age classes and structures).

Minimize vegetation loss.

Workshop 1B

HOW DO WE ESTABLISH BASELINE CONDITIONS TO MEASURE THE SUCCESS OF LANDSCAPE MANAGEMENT?

Need to establish baseline data to measure increase or declines of selected biodiversity attributes.

Identify, inventory, and monitor populations and distributions of TES species, keystone species, indicator species, and sensitive communities (at appropriate spatial and temporal scales).

Study processes and patterns of adjacent, untouched areas (national parks, wilderness areas, roadless areas, RNA's).

Map existing conditions, e.g., species ranges, community types, soils, geology, topography.

Measure the increase of exotic species and recognize the new stresses they impose on "natural" ecosystems.

Assess what the landscape/ecosystem capable of supporting on a sustained basis.

Identify desired future condition for the ecosystem or national forest.

Coordinate with other landowners and agencies.

Workshop 2A

HOW DO WE MANAGE FOR SPECIAL OR LIMITED HABITATS, SUCH AS RIPARIAN AND OLD-GROWTH HABITATS?

Participants in this workshop developed a variety of positive suggestions for classifying and identifying special habitats and then listed some considerations applicable to specific situations.

General

Identify and define what is special or limited both biologically and socially. Specialness is often defined by what is limited. Examples are: old-growth, riparian wetlands, aspen, wooded draws, whitebarked pine communities, grizzly bear denning sites, disjunct communities, elk wallows, caves, bogs, alpine.

Distinguish between special habitats that are unique (e.g., riparian, denning sites) and special habitats that might be increased or be moved around the landscape (wooded draws, whitebarked pine, old-growth).

Establish management allocations, standards and guidelines for special habitats. Define a range of suitability, not just the minimum.

When only the minimum is stated, we seem to always manage for the minimum condition. This is why we've been headed towards minimum biodiversity.

Maintain specialness - different approaches will be required Consider several options: stay out; buffer; use gentle to moderate touch.

When protection is required, preserve the area, set it aside, and have a written record telling why it is important. Maintain its characteristics (comply with laws and regulations).

Manage identified special habitats only for reasons other than for exclusive timber goals.

Prioritize areas that can provide for multiple values/uses

Project proposals should include alternatives that protect and enhance special habitats.

Identify biological traits important to special habitats (e.g., which ones are susceptible to change? which components are limiting?).

Consider how these areas need to be connected in the landscape.

Consider cave habitat in regard to people access, effects caused by runoff entering caves, and the effect of vegetation around caves.

Management

Consider the extent to which managed stands can satisfy the ecological requirements of special or limited habitats.

Preserve all possible options by maintaining the integrity of special habitats within the landscape.

Consider exchange, conservation easements, and co-operative agreements with adjacent landowners.

Many special habitats are small and are inclusions in managed areas.

May need to change managed areas and prescriptions to recognize these inclusions.

Timber Harvest Considerations

Initiate harvests that are not stand replacing (i.e., "New Forestry").

Use silvicultural systems that mimic natural disturbances.

Any salvage or harvest should not deviate from standards in the Forest Plan.

Limit roading and where possible access harvest area from an adjacent unit or by helicopter.

Modify management practices to mimic special or limited habitats, e.g., leave suitable trees for cavity nesters when harvesting timber.

Salvage Operations

Consider that some levels of blowdown, fire, and other natural disasters are acceptable in forest environments .

Strike the word "salvage" from our vocabulary. Often becomes a carte blanc operation.

Do not salvage blowdown and insect and diseased trees solely because they are damaged trees. Sometimes we can walk away.

Riparian

Require special timber marking guides adjacent to streams throughout the Northern Region.

Get rid of existing roads (move roads out of riparian zones).

Equipment restrictions: consider distance from stream, type of equipment, type of soil (substrate) present.

Livestock

Adjust current livestock grazing to protect riparian areas. Make efforts to restore riparian habitats.

Require more herding.

Build watering facilities and salt licks away from riparian areas.

Maintain and restore continuity for riparian/ old growth corridors; minimize roads, dams, and water diversions).

Old-Growth

Prioritize old-growth stands on a landscape scale. Evaluate substructure, soils, flora too -- old-growth is more than just the trees. Determine where commodity extraction can occur.

Allow for old-growth recruitment, consider whether all old-growth stands are even replaceable.

Consider whether 10% is enough to maintain the biodiversity of old-growth, e.g. how many existing stands are rocky hillsides?

Look for opportunities to modify management practices other than set aside. For example, utilize different timber rotation lengths.

Consider location and connectedness (size and shape of stands)

Workshop 2B

HOW DO WE MANAGE FOR IMPORTANT STRUCTURAL COMPONENTS WITHIN HARVESTED HABITATS?

General

Identify specific structural components in each special habitat and determine much of each component is needed.

Consider management in adjacent stands.

Consider effects of pre-commercial thinning in regard to spacing, species diversity, and snag retention.

Trees

Leave a mix of trees including small trees that meet genetic quality standards.

Leave islands of trees.

Leave understory trees in patches. These provide habitat for small mammals as well as hiding cover and shade. Maintain moist micro-habitat patches.

Preserve non-commercial species where desirable to do so.

Look at revising yield tables and reflect in ASQ.

Snags

Snag and deadwood management is not given enough importance. Policy needs improvement. Snags need more protection. Firewood is the problem. (this requires commitment by managers; public education; enforcement).

Manage for future snags and other components. Leave replacement snags (live cull).

Consider genetics in next rotations and avoid dysgenic effects.

Need to recognize species of snag and how long they will last. Lodgepole won't stand long. Get away from broad-brush guidelines. Be species specific.

Leave an adequate number of snags and also assess distribution. Clumping works better.

Assess and resolve conflicts with fire management on snags. Need cooperation.

Leave option of high stumps providing habitat for ants, rodents.

Artificial generation of components should NOT become a substitute for naturally occurring components (strofoam snags, goose nesting boxes). This technique could be used as a short term emergency measure, but should not be considered a "cure".

Down Woody Material

Modify traditional fuel treatment practices. Require a minimum level of fuel to be left on the site. Call for low intensity prescribed burns to mimic natural burns.

Do not allow pulp removal when desirable to leave for habitat structure.

Workshop 3A

LIST QUESTIONS THAT NEED TO BE ADDRESSED IN THE MANAGEMENT OF WILDLIFE BIODIVERSITY.

General

Set rotation ages based on requirements for sustaining long term biological productivity and maintaining biodiversity rather than strictly culmination of mean annual increment (CMAI).

Consider the desired elevation distribution of reserves and connectors (% of forested area by elevation zone) .

Identify critical (key) habitat areas.

Patch Size

Habitat size must be large enough to provide for sensitive species.

Concentrate logging in certain areas and maintain large intact blocks together rather than create patch work within relatively undisturbed or roadless areas.

Leave large blocks.

What is the optimal patch size for the species of interest?

How to manage patch size to accommodate a range of species.

Juxtaposition

Evaluate distances between large blocks in terms of mobility of wildlife species.

How much of the upland do we need to maintain integrity of riparian area.

Old-Growth

Provide for old-growth values through extended rotation networks.

Communities

Look at forest types and maintain representation.

Roads

Minimize roads using forwarders.

Eliminate roads with helicopter logging.

What are impacts of roads crossing corridors.

Edge

Minimize edge effects.

Partial cutting that creates no edge.

Buffering between clearcuts and uncut areas (Multiple Use Modules).

Scales

What are appropriate scales by which to manage wildlife biodiversity?

Choose logical size to manage for majority of species.

Need to look at different scales depending on species (one or more drainages, mountain range, etc...).

Watersheds are the minimum scale necessary to deal with fragmentation.

Wildlife

Consider historic populations of a given area and manage the habitat in such a way that restoration of extirpated species is possible.

Consider what species and population numbers are associated with vegetative communities and seral stages?

Consider what wildlife we have and what species and consider the numbers we want to manage for.

Identify sensitive species and their requirements.

Should the focus of biodiversity be on non-game instead of game?

Snags

Require that snags be managed as a non-delining, even-flow target.

Education emphasis: go to the schools, pass out brochures with firewood permit on the importance of leaving snags.

Raise the fine for cutting snags.

Concentrate in bug kill, fire kill or slash pile areas.

Snags on steep slopes

If leaving live trees, have the contractor mark them.

Leave green buffer trees around high value snags in cable units.

Make leaving snags a requirement of the contract.

Watch follow-up burning practices so you don't lose the snags you leave.

Logs

Down, woody material.

Consider how burning (site prep) will affect woody debris.

Contractor: designate leaving down merchantable timber.

Leave a diversity of woody material - size, etc...

Down, woody material is also needed for fungi, saprophytes/mycotrophs, orchids, and other plant species; need to assess how much and what size.

Leave green, healthy trees through more than one rotation. Consider a longer rotation.

Leave standing cull trees for future down, woody recruitment.

Corridors

Where should be place the corridors.

Enhance those corridors that are not effective and viable and don't meet objectives.

Look for barriers in designing of corridors.

Workshop 4A

HOW SHOULD WE MEASURE AND MONITOR BIODIVERSITY?

Workshop participants demonstrated a good grasp of the problems associated with this question and proposed a variety of useful answers. Almost all considerations express a frustration with the need for more information than is readily available.

Measure

Measure at the ecosystem level (ECODATA) to the specific levels of intensity necessary to achieve our goals.

Add more structural components to stand exam and reforestation exams. Some things that should be included in the inventory: snag retention, down woody debris, residual trees.

Attempt to do one vegetation inventory with the combination of ECODATA and stand exams. Existing inventory efforts need to be more integrated and comprehensive.

Strive for consistency across National Forests and zones.

Map distribution of habitat type/seral stage combinations. Aggregate data to see the pattern on the landscape.

Develop objectives for different scales, e.g. measure fragmentation at landscape scale, measure wet patches at microsite scale.

Tap into already established inventory systems such as the Natural Heritage Program database, ECODATA, Montana Riparian Association, National Wetlands Inventory database (SYS2000).

Monitor

Focus on monitoring ecosystems rather than species. Use key attributes that characterize the ecosystem, such as species and communities and physical features such as soil.

Broaden our functional levels of monitoring to encompass the concepts of biodiversity. This could include monitoring of: water quality, indicator species, forest age class structure, riparian vegetation, dead components, etc...

Monitor key attributes, e.g., management indicator species, or ecosystem under threat (like old-growth).

Monitor attributes that allow you to assess what rate of change is appropriate.

Describe the desired future condition of biodiversity in the Record of Decision rather than making it an alternative or issue in NEPA documents.

Every project needs to be compared to Forest Plan monitoring standards on the ground after implementation. Monitoring reports should detail what didn't work out so well and why.

Do inventory exams in habitats that don't have commercial timber.

Determine threshold for change of ecosystems. Where to stop --bottom line.

Determine degree of disturbance an ecosystem can tolerate in terms of intensity and frequency. Try to replicate key attributes of ecosystem through management.

In the field are existing examples of every kind of activity. We need to look at the effects of all these activities and compile all this data. We need to share information more and be less resistant to using data from other places.

We need to be able to track connectors with such tools as aerial photography, satellite imagery, GIS, TSMRS, etc...

Monitoring plans need to be tiered and coordinated from the landscape level down to the project level.

Use standard technique over time.

Workshop 4B

WHAT IMPORTANT ASPECTS OF BIODIVERSITY ARE NOT BEING MEASURED NOW THAT WE SHOULD BE MEASURING (AND CAN REALISTICALLY EXPECT TO MEASURE) AND HOW SHOULD WE MEASURE THEM?

Monitoring needs to accomplished across legal boundaries (National Forest, private, state).

We are not monitoring connectiveness and this needs to be done at the project level.

We are not monitoring our wetlands to determine if they are increasing or decreasing. The SCS and Corps of Engineers could provide information in this area. Use of the National Wetlands Inventory data base could be a valuable tool.

Monitoring should be budgeted for in multi-phase projects. Monitoring should be made a hard target.

Need good baseline data for species richness and composition.

Need good baseline data on spacial distribution of different units like patches and stands on a large scale.

Effects of various management activities.

Look at landscape level.

Distribution patterns of community levels.

Area-to-edge ratios.

Fragmentation.

Ecosystem data collection.

Create interest from range, wildlife, timber, etc...

Need specific measurements so we can determine if we are moving forward or backward.

Exotic species, e.g., spotted knapweed.

Standardization of methods.

Hire applied statisticians.

Consider contracting for NEPA and free-up technicians and professionals from paper work.

Work more closely with researchers in developing monitoring design.

Incorporate monitoring efforts into project design.

Few inventories in set aside areas, e.g., wilderness areas.

What wildlife occur in what habitats and what is the season of use.

Inconspicuous or non-traditional species (soil organisms, non-vascular plants, non-game species, invertebrates).

Structural stages, (particularly old-growth) and vegetative types.

Stand structure (large woody debris, snags, vertical layering, understory species).

Aquatic and other unique habitats (caves, talus slopes, wetlands, lakes, riparian, old-growth, cliffs, etc...).

Review existing inventories.

Some information can be incorporated into stand exams.

Combine/prioritize into integrated inventories.

Make inventories hierarchical (region/forest-wide/planning area/project).

Use LANDSAT or similar broad landscape (aerial photos) views first.

Broad structure/vegetation types (every EIS/EA should require evaluation at the landscape level).

Pattern, stand size, interconnection.

Include in-holdings and adjacent non-Forest Service (cooperate or not).

Establish, carefully document (GPS, etc...) and commit to revisit permanent plots: change.

Consult and support existing information, e.g., Forest Service data, Natural Heritage Program database, herbaria, University tracking programs.

Rank, prioritize old-growth stands (dbh, height, down/woody material, moist sites). Measure invertebrate and nonvascular plants in old-growth.

Manage for old-growth characteristics on more than just the minimum area required (because of fire and its natural processes).

Assessment and monitoring are project costs. If you can't do or fund assessment/monitoring you shouldn't be doing the project.

Need more partnerships to conduct data collection and manage it.

Tie monitoring into the target system. Develop targets for monitoring plots. Fund it!

We need to continue monitoring into the future - - we stop at three years instead of going for 20 years of data.

Need to map structural diversity and vegetative diversity (easy with SPATIAL). Identify the special habitats (wetlands, lakes, clifflands, etc...). For example, may use color infrared transparencies.

The biggest holes in our inventory efforts are at the landscape level.

Workshop 5A

WHAT ARE THE MOST IMPORTANT PRIORITIES IN BIODIVERSITY FOR THIS REGION?

Change Management Focus

Implement biodiversity now!

Change Forest Plans to incorporate biodiversity. Make biodiversity a National Forest target.

Icorporate biodiversity into our EA's and EIS's.

Incorporate biodiversity considerations throughout the planning process (don't wait for next round of Forest Plans, but start monitoring and evaluating and adopting new standards).

Determine if a new form of organization would better facilitate the forwarding of biodiversity (e.g., a Vegetative Management Group, a Consumer Management Group, more ecologists).

Achieve a level of understanding and commitment such that biodiversity/ecosystem considerations become an integral part of management activities.

Adopt an ecosystem perspective instead of the traditional functional perspective (starting at upper levels of management).

Do away with functional funding and targets and fund for a healthy ecosystem.

Cange the local philosophy from commodity extraction to the maintenance of ecosystem function and productivity. This includes the productivity of commodity and non-commodity items alike in perpetuity.

Let some stands cycle all the way through succession rather than terminating by harvesting (also, do not salvage all blowdowns).

The timber rotation length needs to be set based on biological and biodiversity aspects rather than culmination of mean annual increment.

Remove the most marginal timber sites from the base (or at least recognize the need for a much greater rotation period on such sites and program these limitations into output calculations).

Providing for maintenance of biodiversity at species through landscape levels will likely by default provide for genetic diversity and maintenance of genetic quality.

Education

Conduct workshops and training sessions on management of biodiversity for the Districts, the public, and management (especially line officers/decision makers).

Widely disseminate information concerning TES species, sensitive communities, and key processes maintaining such entities (e.g., natural fire).

Rehabilitation of Disturbed Ecosystems

Begin the rehabilitation of the disturbed ecosystems including aquatic habitats and past mining sites.

Prevent the spread of noxious weeds and other exotic organisms and reclaim lands currently dominated by such organisms.

Intra/Interagency Cooperation

Promote more co-ordination and partnerships with other agencies (including State and private).

Foster co-operation with the research branch of the Forest Service.

Database Development and Anslysis

Develop a single vegetative inventory system.

Develop an inventory system and data base that spans all resources and administrative units.

Develop the necessary data and complete a viability analyses for the Regional Forester's sensitive species list.

Inventory TES species and set up management plans for them.

Develop landscape level maps of structural classes, vegetative types,
and age class distribution.

Identify and inventory ecosystems (e.g., landscape patterns by disturbance process by ecosystem type).

Begin using tools that will display effects at scales broader than stand level (e.g., GIS and successional pathway models).

Develop monitoring plans.

Establish a information clearing house on biodiversity.

Old-Growth/Riparian

Management of old-growth (also, substitute "riparian" for "old- growth" below).

Complete definition and inventory of old-growth.

Develop guidelines for old-growth management.

Assess if existing stands in old-growth allocations actually perform old-growth functions. Some forests have old-growth management areas assigned to stands that are very young (clearcuts).

We need a long term management strategy to ensure we continue to have old-growth in the future.

We need local research on old-growth to create our management guidelines.

We need to assess how old-growth stands in the timber base that are scheduled to be cut fit into our strategy for long term management of old-growth. We are losing options. We need to consider some of these areas (in the base) for long term old-growth allocation.

We need to expand management of special habitats in addition to old-growth or riparian.

Employee Biodiversity Credentials

Hire people with the skills to help achieve biodiversity.

Line officers need to foster a commitment to conservation biology and biodiversity.

Make biodiversity part of decision makers performance elements.

Need biodiversity "litmus test" for new/current employees.

We need to better train/utilize new employees (e.g., incorporate biodiversity into early career duties/training).

NORTHERN REGION BIODIVERSITY WORKSHOP

September 11-13, 1990

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